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Plankton diatom assemblages of the Iowa Lakes Region

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PLANKTON DIATOM ASSEMBLAGES OF THE IOWA LAKES REGION.
(VOLUMES I AND II)

Iowa State University PH.D. 1986

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Plankton diatom assemblages of the

Iowa Lakes Region

by

Greeneville Berkeley Hall

Volume 1 of 2

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of the

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For the Graduate College

Iowa State University
Ames, Iowa

1986

TABLE OF CONTENTS

DEDICATION

To the "THREE-WOMEN-IN-MY-LIFE",

Dad,

and the memories of two special friends,

my mother, Mildred Berkeley Hall,

and

Cameron L. "Chris" Christensen.

INTRODUCTION

The Iowa Lakes Region (Region or Lake District) is located in Dickinson County in Northwestern Iowa (Figure 1). Eight major lakes and numerous wetlands comprise the Region, the only true lake district within a prairie state with few remaining natural lacustrine habitats. Together these basins represent a unique aquatic resource important for fish and wildlife propagation; public water supplies; and recreational usage.

The lakes and sloughs of the Region are classified as eutrophic alkaline waters, although the degree of eutrophication varies. The differences among the lakes are surprising, particularly in light of the rather uniform physicochemical characteristics (Table 1) and land-use practices (Table 2) of this Region (Bachmann and Jones, 1974). Evidence suggests that the lakes have been eutrophic for several thousand years. Sediment analyses in the deepest lake of the Region, Lake West Okoboji, indicated no changes in the sedimentation rate or trophic state, even in the recent deposits (Stoermer, 1963a; Collins, 1968; Dodd, 1971). In addition, the fossil diatom assemblage of this lake is characteristic of nutrient enriched condition (Stoermer, 1963a). Because of its relatively great depth, we may infer that Lake West Okoboji was probably the last lake in the Region to undergo eutrophication.

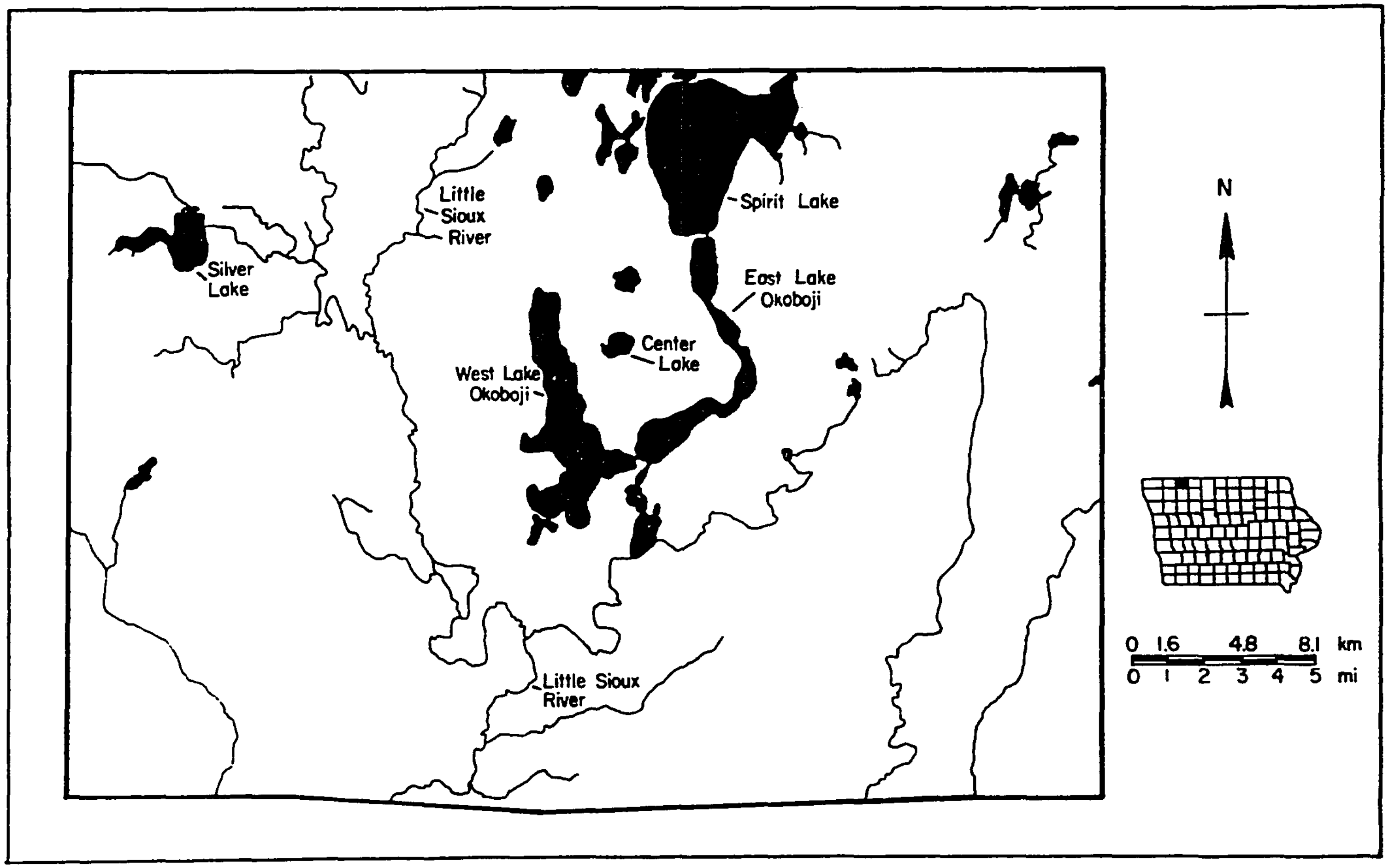

Figure 1. Map of the Okoboji Lake Region, Dickinson County, Iowa

Table 1. Means of limnological measurements made on the major lakes of Dickinson County, Iowa. Data summarized from Jones and Bachmann (1978) and Bachmann et al. (1980). Lake West Okoboji, LWO; Lake East Okoboji, LEO; Spirit Lake, SPI; Center Lake, CEN; Silver Lake, SIL

Parameter	LWO	LEO	SPI	CEN	SIL
Specific Conductance µmhos/cm 25° C	410.8	422.2	426.7	406.1	620.6
Total Hardness mg/l as $CaCO_3$	219.1	230.7	236.4	203.3	345.8
Alkalinity as mg/l $CaCO_3$	201.2	196.3	190.7	178.8	162.8
Calcium Hardness mg/l as $CaCO_3$	78.2	98.7	82.4	50.3	226.0
Magnesium (mg/l)	29.0	31.0	34.0	34.0	34.0
Sodium (mg/l)	10.5	9.5	9.5	13.5	8.5
Chloride (mg/l)	10.3	15.0	16.3	28.3	17.5
Sulfate (mg/l)	26.7	28.7	43.8	5.3	178.7
Total Phosphorus (mg/m^3)	28.5	139.1	67.4	119.8	97.1
Nitrate+Nitrite Nitrogen (mg/l)	0.1	0.7	0.1	0.1	1.2
Kjeldahl N (mg/l)	0.7	1.2	1.1	1.7	1.0
Ammonia Nitrogen (mg/l)	0.1	0.3	0.2	0.1	0.2
Chlorophyll <u>a</u> (mg/m^3)	6.3	25.8	46.2	90.3	34.1
pH	8.2	8.1	8.6	9.1	8.3

Table 2. Estimates of land use (percent) within the Iowa Lakes Region. Data from Bachmann et al. (1980). Lake West Okoboji, LWO; Lake East Okoboji, LEO; Center Lake, CEN; Spirit Lake, SPI; Silver Lake, SIL

Parameters	LWO	LEO	CEN	SPI	SIL
Cropland	83.1	84.5	90.6	89.6	87.7
Pasture	9.7	7.5	5.7	6.5	8.0
Forest	1.1	0.6	0.3	0.4	0.8
Town	2.4	4.0	0.0	0.1	0.0
Other	3.7	3.5	3.4	3.5	3.6

Limnological change has been noted during recent years, however, as evidenced by the increased hypolimnetic oxygen deficit within Lake West Okoboji, attributed to increased primary production in the euphotic zone (Bachmann and Jones, 1974); the decline in the numbers and kinds of molluscs in the Region (Bovbjerg and Ulmer, 1960); and the disappearance of submerged macrophytes in many of the lakes due to "shading-out" by increased phytoplankton abundance (Volker and Smith, 1965; Crum and Bachmann, 1973). During the past century, agricultural intensification within the Region has accelerated the drainage within the basins, which has altered the quantity and quality of the surface runoff. Concomitantly, the concentrations of available plant nutrients appears to have increased within the lakes, because dense nuisance algal blooms have now become the single most important water quality problem. Because nutrients play such a paramount role in determining the water quality, Bachmann and Jones (1974) investigated the potential sources within the Region. Nutrient budgets were determined for each lake basin, and phosphorus was identified as the major element controlling algal growth. Of the sources of phosphorus to the lakes, an average of 80% entered through inflowing streams that drain the water sheds. These findings were similar to those for other Iowa streams draining agricultural lands. They are of more concern in the Lake District, however, because runoff drains into an extensive lake system, rather than directly to a major river. The longer residence time (turnover) of water in the lakes makes them inherently more susceptible to eutrophication.

Bachmann and Jones (1974), in their assessment of water quality in the Lake District, recommended guidelines to prevent its further deterioration. Foremost was the continued reduction of phosphorus inputs to the lakes. Secondly, they recommended that a continuing monitoring program be initiated to measure water quality, algal quantity and composition, with periodic surveys of specific plant and animal groups. As a part of this second recommendation, I conducted a survey of the plankton diatom communities (Bacillariophyta) in the major lakes of the Region (Lake West Okoboji, Lake East Okoboji, Center Lake, Spirit Lake and Silver Lake). The diatoms were chosen because (1) they are perhaps the most important members of the phytoplankton flora of the Lake District; (2) they have been emphasized by previous researchers and, therefore, may serve as a "vehicle" to evaluate ecological changes in the lakes; and (3) more is known about the autecology of diatoms than perhaps any other group of aquatic organisms; and through a careful analysis of the diatom community a great deal can be ascertained about the aquatic habitat.

The research reported here is an attempt to provide a definitive plankton diatom flora for the major lakes of the

Region. Considerable effort has been devoted to determining the relative abundance of the diatom species in the flora, and their temporal distributions. Changes in the diatom flora during the past 20 years are addressed. In addition, the relationships between diatom periodicity and lake morphometry and trophic state are investigated, as well as, the natural thermal tolerances of the major taxa.

LITERATURE REVIEW

Observations on the diatom flora of the Lake District began during the late Nineteenth Century. Myers (1899) published a preliminary report on the diatom flora of Iowa and included taxa collected from the Region. Buchanan (1907) noted the algae from lakes East and West Okoboji and the Gar Lakes. Although he collected a large number of diatoms, only genera were reported. Birge and Juday (1920) identified the genera of plankton in net hauls from Lake West Okoboji, including diatoms.

There exists a gap in the literature from 1920 to the early 1960s when detailed analyses of the diatom flora resumed. Many of the following citations represent research sponsored by the Federal Water Pollution Control Administration (Environmental Protection Agency) entitled, Ecology of Diatoms in Hardwater Habitats (Dodd, 1971). This project was initiated primarily to fill a regional void in our knowledge of Midwestern diatoms.

Volker (1962; 1963) reported on the plankton diatom flora of Lake East Okoboji. These studies represent the only temporal investigations of plankton diatoms in the Region. Stoermer (1963a,b; 1964) studied the post-Pleistocene diatom flora from Lake West Okoboji and included taxa identified from sediment cores and recent collections. Shobe et al. (1963) studied the ecology of diatoms from Silver Lake Fen. Collins

(1968) identified the fossil diatoms in post-glacial sediments from Little Miller's Bay, Lake West Okoboji; and Hostetter and Stoermer (1968) investigated the vertical distribution of periphytic diatoms within the same lake. Common diatom taxa from the plankton, periphyton, and benthic substrates of Big Spirit Lake were reported by Krohn et al. (1974). Hosseini (1979) compared the temporal and spatial changes of periphytic diatom communities collected on artificial substrates in Lake West Okoboji. During his study of the Pinnularia of Iowa, Jackson (1980), made collections from the Region. He also examined specimens contained in the Iowa Lakeside Laboratory Diatom Collection, procured by Dr. Charles Reimer, which represented species collected from the major lakes of the Region. Patrick and Reimer (1966; 1975) have referenced numerous diatom taxa collected from the Lake District, although their method of citation makes it difficult to determine exact distributions. All of these investigations have enhanced our knowledge of the taxonomy, distribution, and ecology of North American diatoms.

MATERIALS AND METHODS

The Study Area

Geography and land use

The Iowa Lakes Region is located in four townships of north-central Dickinson County, with portions of the watersheds extending into Jackson County, Minnesota (Figure 1). Eight major lakes lie within the Region: Lake East Okoboji; Lake West Okoboji; Upper Gar Lake; Lake Minnewashta; Lower Gar Lake; Center Lake, Spirit Lake; and Silver Lake. With the exception of Silver Lake, all of these lakes share a common watershed (Figure 1) forming the headwaters of the East Branch Little Sioux River. The Silver Lake drainage enters the West Branch Little Sioux River approximately 12 miles (19km) upstream of its confluence with the East Branch. The Little Sioux River is a tributary of the Missouri River.

The combined watershed area for the Region is approximately 154 square miles (400 km^2), with land area and area of lakes, ponds and marshes comprising approximately 80% and 20% of the total, respectively. Most of the land area within the watersheds is devoted to row crop agriculture or pastureland (Table 2). Other land uses include approximately 4% urban development, 2% marshlands, and $\leq$ 1% native woodlands (Bachmann and Jones, 1974).

Geology

The Des Moines Lobe of the Wisconsin glacial drift sheet reached its southernmost limit in Central Iowa (Figure 2). The Lake District lies on the Cary glacial drift of the Des Moines lobe (Carman, 1917; Ruhe, 1952), and the lake basins are relics of glacial retreat within the morainal topography. Radiocarbon dating of lake sediments within the Region indicated a post-glacial (late Pleistocene) age (Dodd et al., 1968). Thomas (1913) and Tilton (1916a,b) have described the glacial activities that created the present lake features.

Climatology and meteorology

Iowa's climate is classified as humid continental, characterized by wide variations in daily and seasonal conditions. The mean temperature is 7.4°C, with a minimum of -26.7°C and a maximum of 37.8°C. Total annual precipitation exceeds 93 cm per year. Rainfall and snowfall account for 93% and 7% of the total precipitation, respectively. During this investigation, the lakes had an ice-cover from late December through mid-March, with a maximum ice thickness of approximately 32 inches (0.8 m). The intensity and duration of the winter freezing varies with the year.

Basin morphometry

Morphometric characteristics for each of the lakes investigated are summarized in Table 3.

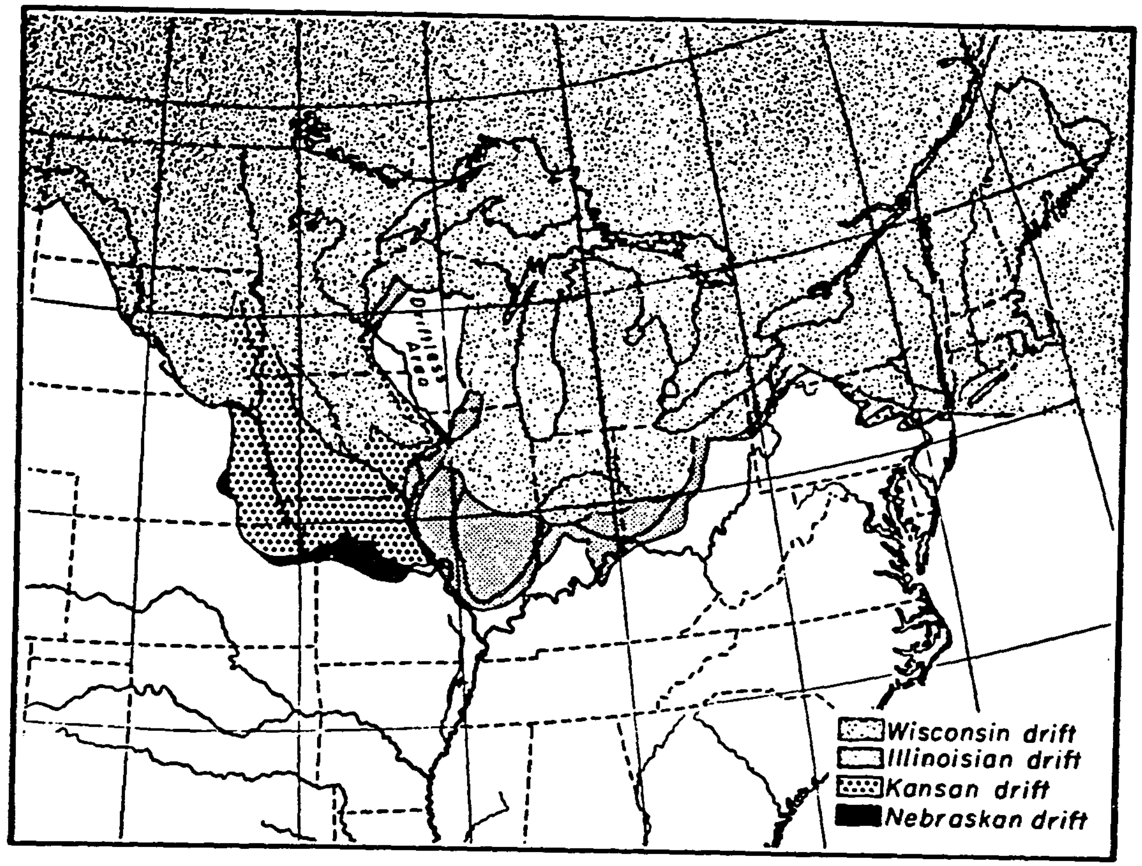

Figure 2. Map showing the southern limits of the four major ice advances (after Flint, 1957)

Table 3. Morphometric characteristics for the lakes investigated during 1979-1980. Data summarized from Jones and Bachmann (1978) and Bachmann et al. (1980). Lake West Okoboji, LWO; Lake East Okoboji, LEO; Center Lake, CEN; Spirit Lake, SPI; Silver Lake, SIL

Parameters	LWO	LEO	CEN	SPI	SIL
Watershed Area (ha)	5531	4942	399	13,950	4490
Surface Area (ha)	1540	764	114	1688	432
Volume (x $10^6 m^3$)	178.6	23.5	3.1	116.1	7.8
Shoreline (km)	31.9	27.1	4.2	26.3	15.5
Shoreline Development	2.3	2.8	1.2	1.6	2.1
Maximum depth (m)	41.5	6.7	4.6	7.3	3.4
Mean depth (m)	11.5	3.2	3.5	5.3	1.8

Lake West Okoboji (Figure 3) (Latitude 43° 23'N, Longitude 95° 9'W) is located in Township 99N, Range 37W, Section 24. This lake is the deepest Iowa lake; has the largest volume; the longest shoreline; the smallest watershed area to lake volume ratio; and is notable as the only natural Iowa lake to experience prolonged summer thermal stratification. Lake West Okoboji has been designated as high quality water and is subject to higher standards to protect existing uses.

Lake East Okoboji (Figure 4) (Latitude 43° 24' N, Longitude 95° 5' W) is located in Township 99N, Range 36W, Section 15. This lake has the greatest shoreline development and ranks second with respect to the watershed area to lake volume ratio (Table 3). Lake East Okoboji is designated as high quality water subject to higher standards of protection.

Center Lake (Figure 5) (Latitude 43° 25'N, Longitude 95° 8'W) is located in Township 99N, Range 36W, Section 7. It is the smallest lake studied and correspondingly has the smallest watershed area, surface area, volume, and shoreline length. Center Lake is also the only other lake in the Region to experience periods of thermal stratification.

Spirit Lake (Figure 6) (Latitude 43° 28'N, Longitude 95° 6'W) is located in Township 100N, Range 36W, Section 16. This lake has the largest surface area of any natural Iowa lake, and the most extensive watershed in the Lake District (Table

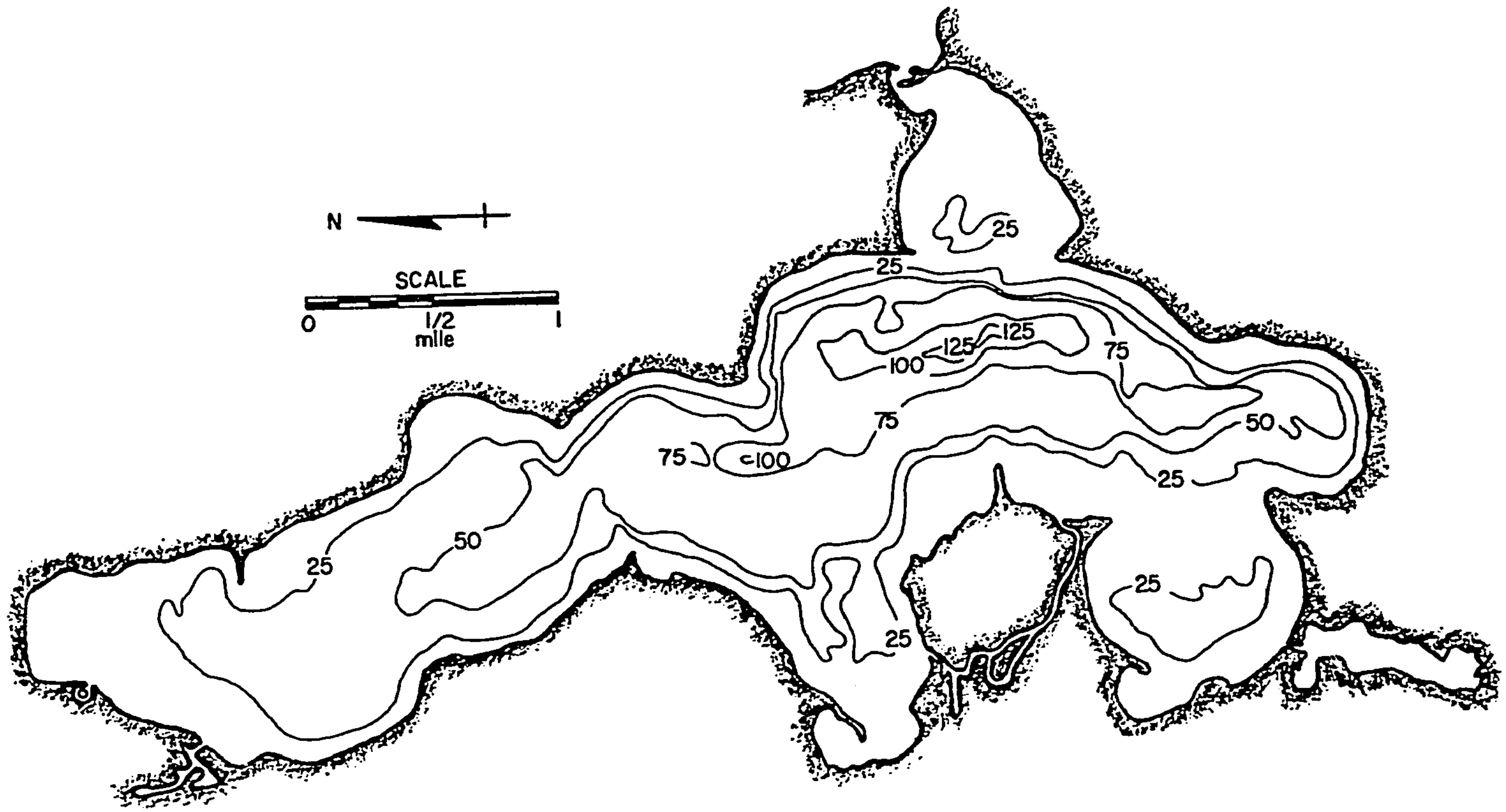

Figure 3. Morphometric map of Lake West Okoboji. Contours are at 25 ft intervals. Scale conversions: 25 ft = 7.6 m

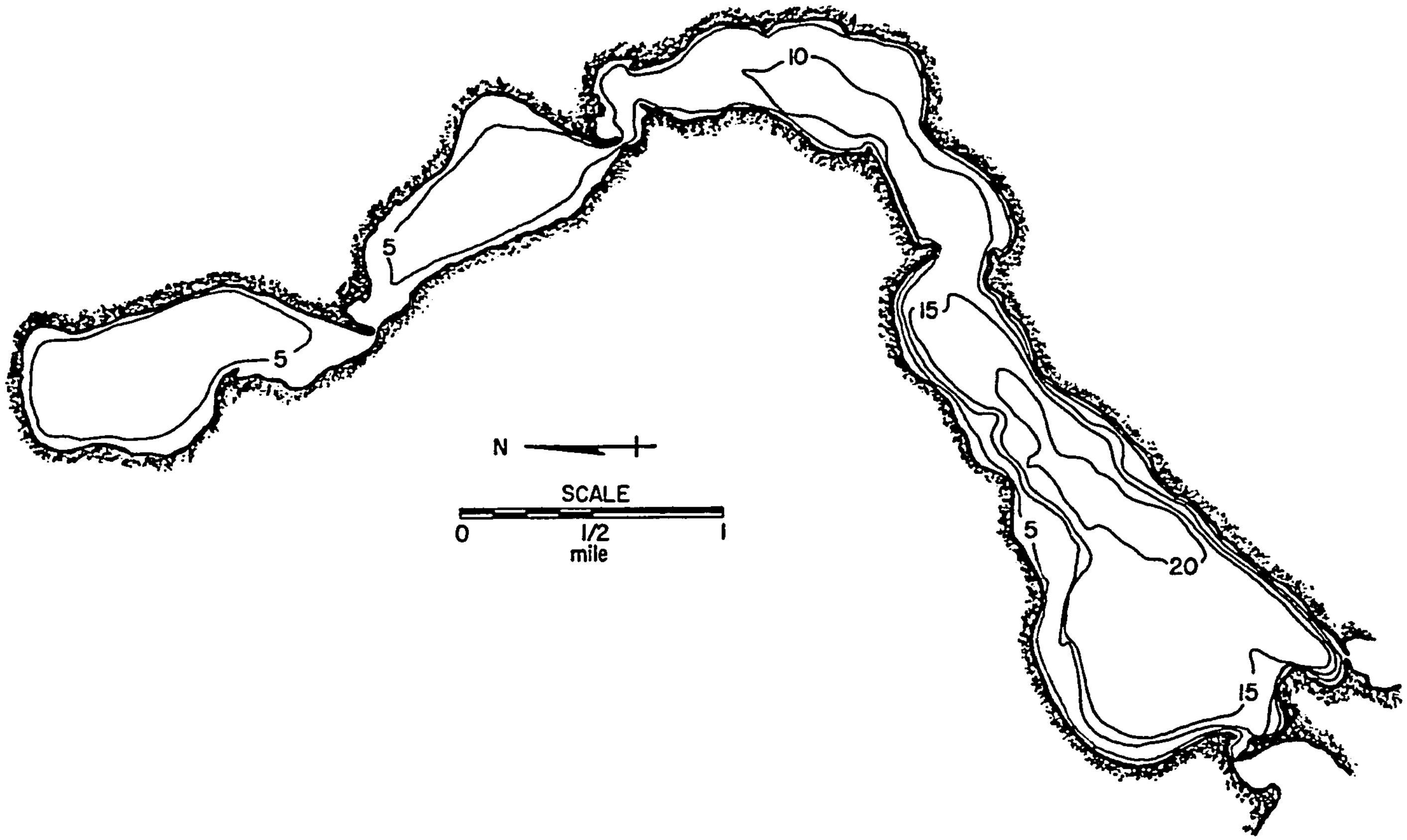

Figure 4. Morphometric map of Lake East Okoboji. Contours are at 5 ft intervals. Scale conversions: 5 ft = 1.5 m

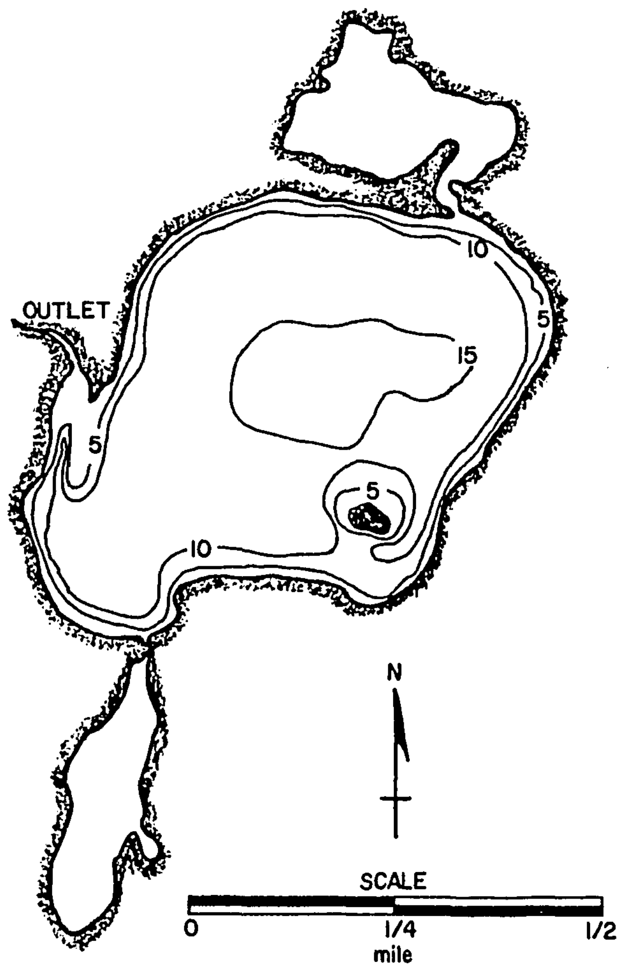

Figure 5. Morophometric map of Center Lake. Contours are at 5 ft intervals. Scale conversions: 5 ft = 1.5 m

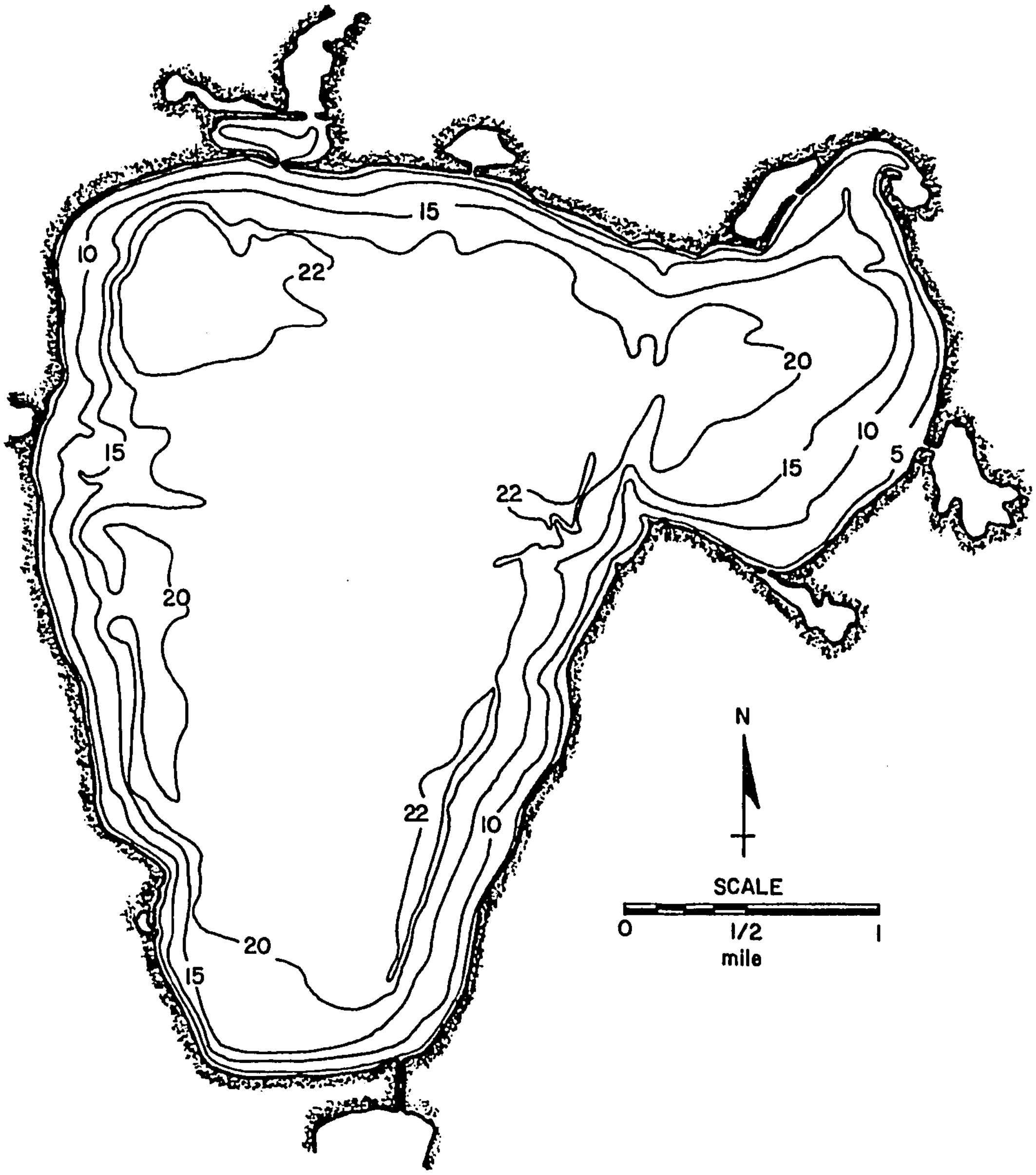

Figure 6. Morphometric map of Spirit Lake. Contours are at 5 ft intervals. Scale conversions: 5 ft = 1.5 m

3). Spirit Lake has also been designated as high quality water, and it is subject to higher standards to protect the existing uses.

Silver Lake (Figure 7) (Latitude 43° 27'N, Longitude 95° 20' W) is located in Township 100N, Range 38W, Section 28. It is the shallowest basin in the Region, and has the largest watershed area to Lake volume ratio (Table 3). Silver Lake serves as a raw drinking water supply for the town of Lake Park.

Physicochemical water quality

Temperature The surface water temperatures followed the seasonal cycle of the ambient air temperature, ranging from 2.5°C (0°C at the surface) during the winter to a maximum between 22° to 26°C during mid-summer (Figure 8). Spring is the warming period and fall is the cooling period. Due to its large volume, Lake West Okoboji warmed and cooled more slowly than the other lakes. Silver Lake generally showed the opposite trend due to its large surface area to volume ratio (Table 3). After sufficient cooling through the late fall, ice covers each of the lakes by late December, increasing in thickness throughout the winter. The timing of ice "break-up" in the spring varies due to climatic conditions and also within and between the lakes, but usually occurs during March or April (Bachmann and Jones, 1974).

Only Lake West Okoboji and Center Lake became thermally

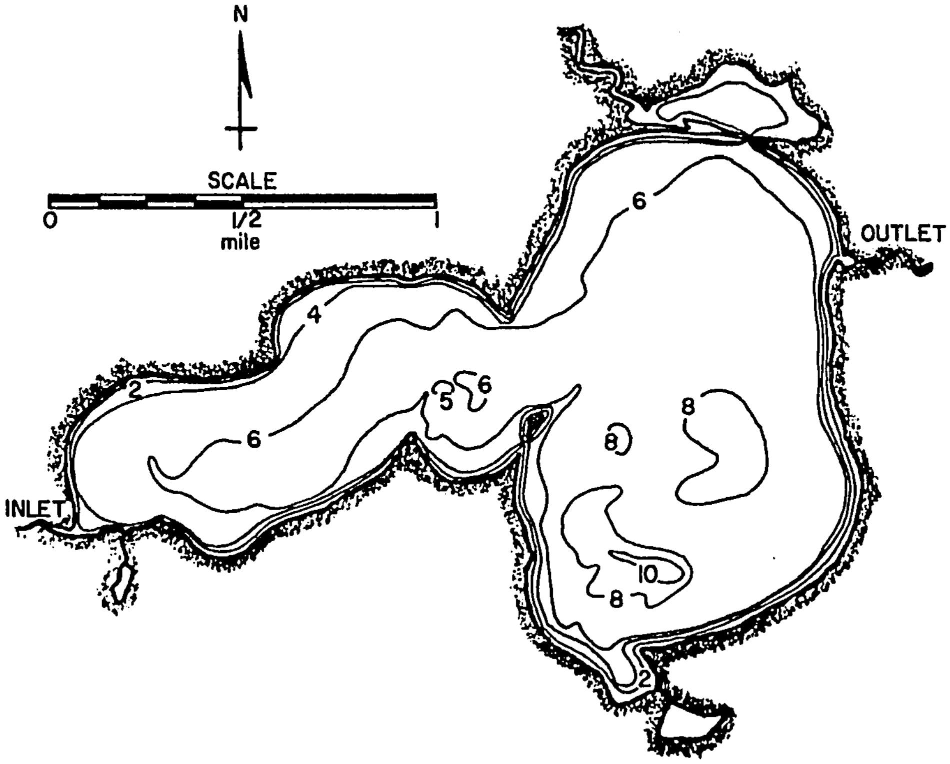

Figure 7. Morphometric map of Silver Lake. Contours are at 5 ft intervals. Scale conversions: 5 ft = 1.5 m

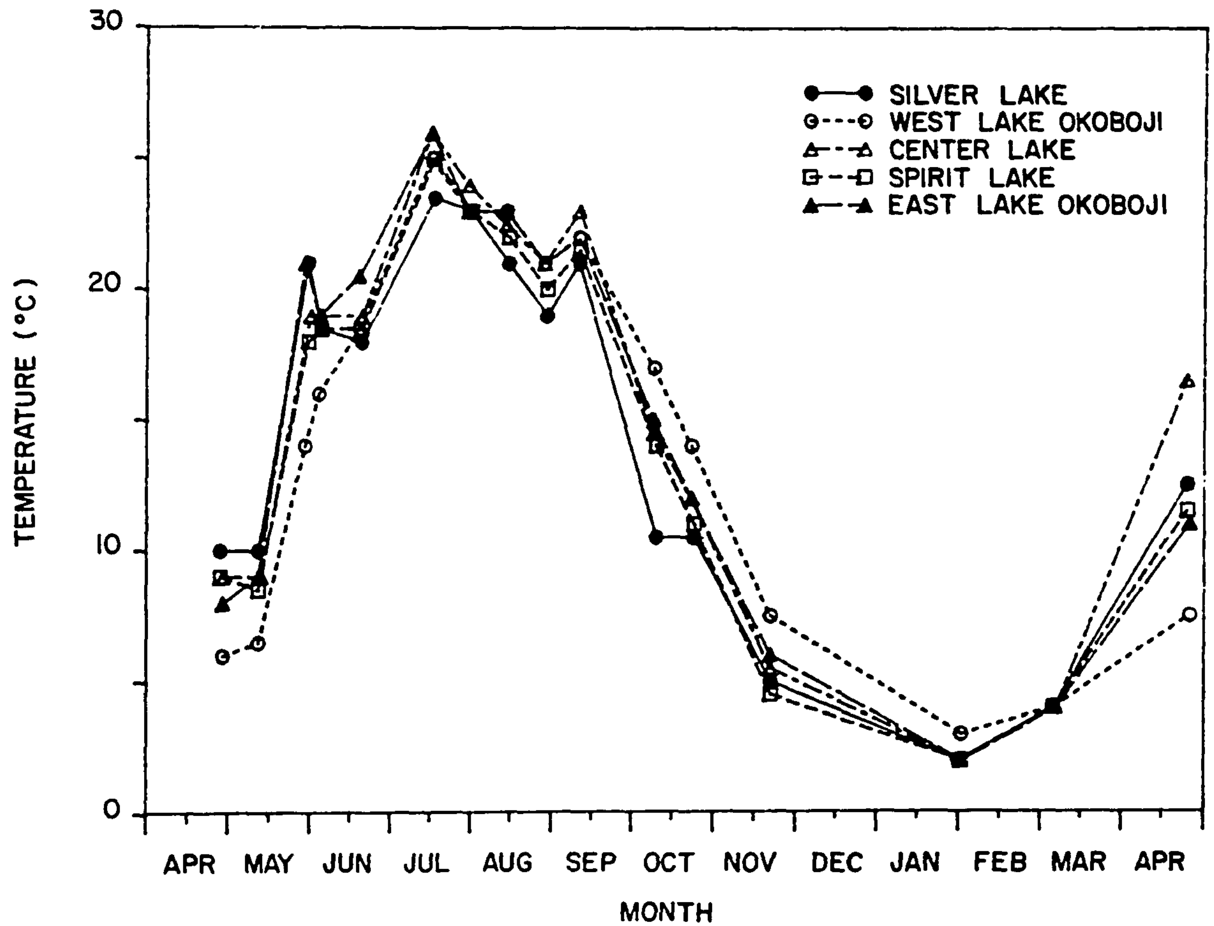

Figure 8. Cycles of ambient surface water temperatures within the lakes. April 1979 through April 1980

stratified during the present study. Center Lake showed only a temporary period of stratification during the late summer. This lake is relatively protected from prevailing winds and has a large mean depth in relation to many of the other lakes (Table 3).

Transparency and turbidity Bachmann and Jones (1974) reported that transparency varied among and within each lake temporally. Transparency followed the same general pattern in each lake, with the lowest values occurring during the summer when algal activity was greatest. Transparency increased during the fall with the greatest values during ice cover and in the early spring. They linked algal standing crop as the controlling factor in determining water clarity in the Lake District. Chlorophyll a concentrations showed a significant negative ($p= 0.01$, $r = -0.86$) correlation with transparency. Inorganic turbidity played an insignificant role in determining water clarity (Bachmann and Jones, 1974).

Dissolved oxygen Dissolved oxygen concenrations in all the unstratified lakes and above the thermocline in Lake West Okoboji varied little between the surface and the bottom samples, due to continual mixing by wind action (Bachmann and Jones, 1974). Exceptions to this have occurred during the peak of algal blooms, particularly in Lake East Okoboji and Silver Lake. Dissolved oxygen concentrations in the surface waters of these lakes greatly exceeded the saturation value, while bottom waters were markedly undersaturated. Similar conditions have occurred during winter stratification (ice cover). Conversely, dissolved oxygen concentrations have been so reduced under winter ice in Silver Lake that fish kills have occurred.

Plant nutrients In Iowa, variations in the physicochemical nature of surface waters are associated with the past glaciation pattern (Jones and Bachmann, 1978). Drift from the Wisconsin glacier (Figure 2) covers much of central and northern Iowa, and this relatively young material is rich in plant nutrients. Soils in southern Iowa are derived from glacial till of the Kansas Ice Age of the early Pleistocene (Figure 2), and have been extensively leached and are therefore poorer in available nutrients. In comparing lakes on and off the Wisconsin Lobe, Bachmann (1965) and Jones and Bachmann (1978) showed that lakes on the Lobe had significantly greater concentrations of plant nutrients, and as a group were more productive (Table 1).

The high concentrations of phosphorus, nitrogen (both inorganic and organic), and silica place these lakes, by conventional criteria, in the category of eutrophic (Table 1; Vollenweider, 1968; Shapiro et al., 1975; USEPA, 1975; Wetzel, 1975). Phosphorus concentrations appear to account for the differences in algal biomass observed among the lakes (Jones and Bachmann, 1978). Previous reseach on Iowa lakes showed a highly significant correlation between the total phosphorus concentration and the summer algal standing crop, as measured by chlorophyll a concentrations (r = 0.93) (Jones and Bachmann, 1975; 1976). High phosphorus concentrations and attendant high densities of plankton algae constitute the major water quality problem in Iowa lakes (Jones and Bachmann, 1978).

Field Collections

Routine field collecting was initiated during April 1979 and continued for the period of one year. Qualitative plankton samples were collected semimonthly, except when weather condtions were unfavorable, from each of the five lakes, by making repetitive vertical hauls with a 37 um aperture plankton net. During periods of ice cover, the plankton net was forced through a 20 cm diameter hole cut through the ice with a gas-powered ice drill. Temperature was recorded at the time of collection with a field thermometer suspended 1/2 meter below the lake surface.

Immediately upon returning to the Lakeside Laboratory, the fresh plankton samples were examined microscopically to determine the kinds of algae present. Aliquots from each sample were preserved with Transeau's solution (6:3:1 - 6 parts plankton samples : 3 parts 95% ethyl alcohol : 1 part formaldehyde) and stored in labeled vials for permanent slide preparation. The remainder of the sample was used to prepare permanent diatom slides.

Permanent Slide Preparations

Permanent microscope slides of planktonic diatoms were prepared by the following procedures.

Diatom "burn" mounts

Aliquots of fresh plankton samples were evenly distributed onto the surfaces of No. 1, 18 mm square coverglasses, partially flooded with distilled water. These sub-samples were well-mixed, allowed to air-dry, and incinerated in a muffle furnace at 500°C for one half-hour. The coverglasses were cooled and mounted on a glass slide in Hyrax (Custom Research and Development, Inc., California). This technique preserves the colonial integrity of diatom species and is useful for permanently mounting lightly silicified species.

Diatom "clean" mounts

Diatom samples were "cleaned", i.e., all cellular organic materials were removed, using the strong exothermic reaction between organic matter and 30% hydrogen peroxide and a strong oxidizing agent, potassium dichromate (van der Werff, 1955). Following repeated rinses with deionized water, the "cleaned" diatom valves were evenly distributed onto No. 1, 18 mm square coverglasses, partially flooded with distilled water; air-dried; and mounted on a glass slide with Hyrax.

Counting Techniques and Photomicroscopy

In order to determine the proportional representation of the major diatom taxa, 600 valves were identified and counted from each plankton collection using oil immersion (1250x). A starting point was selected at random on a permanent, "cleaned" diatom slide, and each valve was identified and tallied until a total of 300 valves were enumerated. This procedure was followed for each of two duplicate slides. In the event that the density of valves on a slide was exceptionally sparse, three transects of 10 mm length were examined. "Burn mount" preparations of diatoms were examined as an aid in taxonomy and for the presence of lightly silicified forms which would be destroyed during the more rigorous cleaning process.

All specimens were examined with a Leitz Laborlux research microscope equipped with a 95x (1.32 n.a.) fluorite oil objective, and a 1.25 n.a. oil immersion condenser. Photographs were taken with a Leitz 35 mm Micro Ibso attachment, using Kodak Technical Pan film 2415 (Eastman Kodak), attached to the Laborlux or Zeiss UPL-inverted microscope (equipped with an achromatic/aplantic phase contrast condenser, 1.40 n.a., and a Neofluatar 100x, 1.30 n.a., phase, oil immersion objective.

Specimen Preparation for Electron Microscopy (EM)

Transmission electron microscopy (TEM)

Preparation of samples for TEM followed the techniques outlined by Kay (1965). Small drops of the peroxide-cleaned diatom suspensions were placed on formvar coated 200 mesh copper grids. These suspensions were air-dried and then placed in a Varian VE-30M vacuum evaporator for carbon coating. Approximately 8 mg of carbon were evaporated at a distance of 18 cm from the grids while the grids were rotated. This process was repeated producing a carbon coating approximately 170 Å thick on the grids. The formvar coating was removed by placing the grids in a petri dish containing chloroform-soaked filter paper for five minutes. The grids were then floated on the surface of a 7% hydrofluoric acid solution for 30 minutes to dissolve the diatom frustules. At this stage of the procedure, only the fragile carbon replicas of the diatoms remained. The grids were washed by floating them on the surface of deionized water. The grids were air-dried and shadowed with a 60:40 gold:paladium alloy in a vacuum evaporator. The alloy was evaporated at an angle of 35 relative to the grid surfaces, at a distance of 8 cm from the grids. This produced a metal coating on the grids approximately 30 Å thick. A Hitachi HS-8 transmission electron microscope was used to examine and photograph the carbon replicas.

Scanning electron microscopy (SEM)

Peroxide cleaned diatom suspensions were filtered onto 10 mm diameter pieces of 0.2 µm aperture Nucleopore filters (Nucleopore Corporation) and air-dried. Each 1.0 cm diameter filter was sectioned into 0.16 cm squares, and each square was mounted onto specimen stubs with silver paint. These preparations were air-dried for 24 hours, and coated with approximately 300 Å of gold in a Polaron E5100 sputter coater. The samples were examined and photographed with a JEOL-35 scanning electron microscope at 15 or 20 Kv.

Statistical Procedures

Cluster analyses, procedures which assign objects to groups in such a way that each group reveals some distinct characteristic of a sample (Orloci, 1978), were performed with a computer package of Bloom et al. (1977), using the Czekanowski Similarity Index (Cormack, 1971). Lakes were clustered using all diatom taxa whose relative abundance was $\geq$ 5% after all manipulations, i.e., calculations of means, were completed.

Other statistical computations, i.e., correlations, linear regressions, and analysis of variance, were carried out using the MINITAB statistical package (Statistical Department, The Pennsylvania State University).

RESULTS AND DISCUSSION

Systematics and Autecology

Two hundred and forty-eight diatom taxa encompassing 33 genera, 11 families, and 7 orders were identified. A systematic list of the taxa arranged according to the nomenclature of Patrick and Reimer (1966; 1975) is presented in Table 4. The symbols (+) indicate in which lakes each of the taxa were collected during the study. Table 5 lists the total number of taxa per genus, as well as, the number of taxa per genus for each lake sampled. Spirit Lake had the largest number of taxa recorded, and Center Lake had the fewest.

The following section is an alphabetical listing of all the entities encountered during the investigation. A short description of each taxon is presented and includes the critical reference and illustration used for identification; taxonomic and autecology information; morphological measurements of specimens from the Lake District; and a distribution table summarizing the occurrence of the taxon in the lakes. A plot showing the temporal distribution and temperatures of occurrence are also included for many of the taxa. With regard to my comments on the distribution and abundance of the diatom taxa, the following terms and definitions apply:

Rare (r) -- occurring 1 to 5 times in a count of approximately 600 values,

Table 4. Systematic list of plankton diatoms collected in the study areas. The '+' indicates in which lakes the diatom taxa were collected. Lake West Okoboji, LWO; Lake East Okoboji, LEO; Center Lake, CEN; Silver Lake, SIL; Spirit Lake, SPI

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Division Bacillariophyta					
Class Bacillariophyceae					
Order Eupodiscales					
Family Coscinodiscaceae					
Subfamily Melosiroideae					
Melosira ambigua	+	+	+	+	
Melosira granulata	+	+	+	+	+
Melosira granulata v. angustissima	+	+	+		+
Melosira islandica		+			
Melosira italica	+	+			+
Melosira varians		+		+	
Subfamily Coscinodiscoideae					
Cyclotella bodanica					+
Cyclotella comta				+	
Cyclotella meneghiniana	+	+	+	+	+
Cyclotella michiganiana	+			+	+
Cyclotella stelligera				+	
Cyclotella striata		+	+		
Stephanodiscus hantzschii	+	+	+	+	+
Stephanodiscus minutus	+	+	+	+	+
Stephanodiscus niagarae	+	+	+	+	+
Stephanodiscus niagarae v. magnifica	+	+	+	+	+
Stephanodiscus tenuis	+	+	+	+	+
Order Fragilariales					
Family Fragilariaceae					
Subfamily Diatomideae					
Diatoma vulgare	+	+			+
Meridion circulare	+				
Meridion circulare v. constricta				+	

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Subfamily Fragilarioideae					
Asterionella formosa	+	+	+	+	+
Fragilaria brevistriata	+	+	+	+	+
Fragilaria brevistriata v. capitata	+				
Fragilaria brevistriata v. inflata	+	+	+	+	+
Fragilaria capucina				+	+
Fragilaria capucina v. mesolepta	+	+	+	+	+
Fragilaria construens	+	+	+	+	+
Fragilaria construens v. binodis	+	+	+	+	
Fragilaria construens v. venter	+				+
Fragilaria crotonensis	+	+	+	+	+
Fragilaria crotonensis v. oregona					+
Fragilaria lapponica	+			+	+
Fragilaria pinnata					
Fragilaria pinnata v. intercedens				+	+
Fragilaria pinnata v. lancettula	+			+	+
Fragilaria vaucheriae	+	+	+	+	+
Fragilaria virescens	+			+	
Opephora martyi	+				+
Synedra acus	+	+	+	+	+
Synedra cyclopum	+	+			+
Synedra cyclopum v. robustii		+			
Synedra delicatissima v. angustissima	+				+
Synedra filiformis	+	+	+		+
Synedra parasitica		+			
Synedra rumpens v. familiaris					+
Synedra rumpens v. fragilarioides	+	+	+	+	+
Synedra rumpens v. scotica					+
Synedra socia	+	+	+	+	+
Synedra ulna	+	+	+	+	+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Order Eunotiales					
Family Eunotiaceae					
Subfamily Eunotioideae					
Eunotia curvata				+	
Eunotia glacialis	+				
Order Achnanthales					
Family Achnanthaceae					
Subfamily Achnanthoideae					
Achnanthes affinis	+				
Achnanthes clevei	+	+	+	+	+
Achnanthes clevei v. rostrata		+			+
Achnanthes conspicua	+	+	+	+	+
Achnanthes exigua v. heterovalva			+		
Achnanthes haukiana		+			
Achnanthes haukiana v. rostrata		+		+	
Achnanthes lanceolata	+	+	+	+	+
Achnanthes lanceolata v. dubia	+				+
Achnanthes lanceolata v. omissa	+	+			
Achnanthes lapponica v. ninckei					+
Achnanthes linearis f. curta					+
Achnanthes minutissima	+	+	+	+	+
Achnanthes sp. #1	+	+	+		+
Achnanthes sp. #2	+				+
Achnanthes sp. #3					+
Rhoicosphenia curvata	+	+	+	+	+
Subfamily Cocconeioideae					
Cocconeis diminuta	+	+		+	
Cocconeis disculus	+	+			+
Cocconeis hustedti		+			
Cocconeis pediculus	+	+	+	+	+
Cocconeis placentula	+	+	+	+	+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Cocconeis placentula v. euglypta	+	+	+	+	+
Cocconeis placentula v. lineata	+	+	+	+	+
Order Naviculales					
Family Naviculaceae					
Subfamily Naviculoideae					
Amphipleura pellucida			+		
Anomoeoneis vitrea					+
Caloneis bacillum	+			+	
Caloneis clevei v. uruguayensis				+	
Caloneis ventricosa					+
Diploneis oculata					+
Gyrosigma attenuatum	+				+
Gyrosigma sciotense		+			
Gyrosigma spencerii		+	+		
Gyrosigma sp. #1		+			
Neidium iridis		+		+	
Neidium iridis v. ampliatum			+		
Neidium sp. #1				+	
Navicula biconica				+	
Navicula capitata		+		+	+
Navicula capitata v. hungarica				+	+
Navicula cocconeiformis	+			+	
Navicula cryptocephala	+	+	+		+
Navicula cryptocephala v. veneta	+	+	+	+	+
Navicula cuspidata	+	+		+	+
Navicula decussis	+	+		+	+
Navicula elata				+	
Navicula exigua v. capitata		+			
Navicula gottlandica	+				+
Navicula graciloides	+	+		+	+
Navicula laevissima					+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Navicula lanceolata		+		+	
Navicula latens	+				
Navicula menisculus	+				+
Navicula minima	+				
Navicula mucicoloides		+			+
Navicula mutica				+	
Navicula nigrii		+		+	
Navicula pelliculosa			+		
Navicula placentula	+			+	
Navicula placentula f. rostrata					+
Navicula platycephala				+	
Navicula pseudoreinhardtii		+	+	+	
Navicula pupula	+			+	
Navicula pupula v. capitata	+				
Navicula pupula v. elliptica	+				+
Navicula pygmea	+				+
Navicula radiosa	+			+	
Navicula radiosa v. parva		+		+	
Navicula radiosa v. tenella				+	+
Navicula reinhardtii		+			+
Navicula salinarum v. intermedia	+	+		+	+
Navicula scutelloides	+	+			+
Navicula simplex					+
Navicula stroesei	+				
Navicula subrotundata	+	+			
Navicula tantula		+			
Navicula tripunctata	+	+		+	+
Navicula tripunctata v. schizonemoides				+	
Navicula tuscula	+			+	+
Navicula tuscula f. minor	+				+
Navicula tuscula v. rostrata					+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Navicula viridula v. argunensis				+	
Navicula sp. #1		+			+
Navicula sp. #2		+	+	+	
Navicula sp. #3	+	+			
Navicula sp. #4	+	+			
Navicula sp. #5		+			
Navicula sp. #6		+			
Navicula sp. #7		+			
Navicula sp. #8		+			
Navicula sp. #9				+	
Navicula sp. # 10				+	+
Navicula sp. # 11				+	
Navicula sp. # 12	+				
Navicula sp. # 13	+				
Navicula sp. # 14					+
Navicula sp. # 15					+
Pinnularia brebissonii					+
Pinnularia maior		+			
Pinnularia viridis			+	+	
Pinnularia sp. #1		+			
Family Entomoneidaceae					
Subfamily Entomoneioideae					
Entomoneis ornata		+	+	+	
Family Gomphonemaceae					
Subfamily Gomphonemoideae					
Gomphonema acuminatum f. brebissonii	+	+	+	+	+
Gomphonema affine				+	
Gomphonema angustatum		+		+	
Gomphonema angustatum v. citera	+	+		+	+
Gomphonema angustatum v. intermedia				+	
Gomphonema clevei					+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Gomphonema dichotum				+	
Gomphonema gracile					+
Gomphonema intricatum	+			+	
Gomphonema intricatum v. pumila	+				
Gomphonema intricatum v. vibrio					+
Gomphonema olivaceoides		+			+
Gomphonema olivaceum	+				+
Gomphonema parvulum				+	
Gomphonema subclavatum v. comutatum				+	
Gomphonema subclavatum v. mexicanum		+		+	+
Gomphonema tergestinium	+				
Gomphonema truncatum	+				
Gomphonema sp. #1		+		+	+
Gomphonema sp. #2		+			+
Gomphonema sp. #3	+	+		+	
Gomphonema sp. #4		+			
Gomphonema sp. #5		+			
Gomphonema sp. #6	+	+	+	+	
Gomphonema sp. #7				+	
Gomphonema sp. #8				+	
Gomphonema sp. #9				+	
Gomphonema sp. #10	+				+
Gomphonema sp. #11	+				+
Gomphoneis erinse				+	
Family Cymbellaceae					
Subfamily Cymbelloideae					
Amphora ovalis	+			+	
Amphora ovalis v. affinis	+	+		+	+
Amphora ovalis v. pediculus	+	+	+	+	+
Amphora perpusilla	+	+		+	+
Amphora veneta	+	+	+	+	+
Cymbella affinis					+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Cymbella aspersa					+
Cymbella cistula	+			+	+
Cymbella cuspidata					+
Cymbella cymbiformis			+		+
Cymbella lanceolata	+				+
Cymbella mexicana	+	+		+	+
Cymbella microcephala				+	+
Cymbella minuta		+			
Cymbella minuta v. silesiaca	+	+			+
Cymbella muelleri	+				+
Cymbella muelleri v. ventricosa					+
Cymbella prostrata	+			+	
Cymbella proxima	+		+		
Cymbella sinuata		+			+
Cymbella triangulum		+		+	+
Family Epithemiaceae					
Subfamily Epithemioideae					
Epithemia adnata v. porcellus			+		
Epithemia intermedia	+				
Epithemia oscellata	+				
Epithemia turgida					+
Epithemia turgida v. westermanii	+			+	
Subfamily Rhopalodioideae					
Rhopalodia gibba					+
Order Nitzschiales					
Family Nitzschiaceae					
Subfamily Nitzschioideae					
Nitzschia acicularis	+	+			+
Nitzschia acuta		+	+	+	
Nitzschia amphibia	+	+	+	+	+
Nitzschia angustata		+		+	+
Nitzschia capitellata				+	+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Nitzschia commutata	+			+	
Nitzschia dissipata	+	+	+	+	+
Nitzschia filiformis	+	+			+
Nitzschia fonticola	+	+		+	+
Nitzschia frustulum v. perpusilla					+
Nitzschia gracilis	+				
Nitzschia hungarica	+			+	+
Nitzschia intermedia		+			
Nitzschia kutzingiana	+				
Nitzschia linearis		+	+	+	+
Nitzschia palea	+	+	+	+	+
Nitzschia pseudoamphioxys		+		+	
Nitzschia recta		+		+	
Nitzschia sigma		+		+	
Nitzschia sigmoidea	+	+	+	+	+
Nitzschia sinuata v. tabellaria		+			
Nitzschia subtilioides	+	+		+	+
Nitzschia subrostratoides					+
Nitzschia triblionella v. levidensis	+				
Nitzschia vermicularis	+				
Nitzschia sp. #1		+			
Nitzschia sp. #2	+				+
Nitzschia sp. #3	+				
Cymbellonitzschia diluviana		+			
Order Surirellales					
Family Surirellaceae					
Subfamily Surirelloideae					
Cymatopleura cochlea		+		+	+
Cymatopleura elliptica				+	
Cymatopleura solea	+	+	+		+
Surirella angusta	+	+	+	+	+
Surirella biseriata f. punctata				+	+

Table 4. continued

Taxonomic Category	LWO	LEO	CEN	SIL	SPI
Surirella guantanalensis	+				
Surirella iowensis			+	+	
Surirella ovata		+			
Surirella ovata v. pinnata				+	
Subfamily Campylodiscoideae					
Campylodiscus noricus v. hiberica		+		+	

Table 5. List of genera observed in the study area showing the total number of taxa within each genus and the distribution of these taxa in each lake investigated. Lake West Okoboji, LWO; Lake East Okoboji, LEO; Center Lake, CEN; Spirit Lake, SPI; Silver Lake, SIL

Genus	No. of Taxa/Genus	No. of Taxa/Genus/Lake LWO	LEO	CEN	SPI	SIL
Achnanthes	16	9	9	6	11	5
Amphipleura	1			1		
Amphora	5	5	4	2	4	5
Anomoeoneis	1				1	
Asterionella	1	1	1	1	1	1
Caloneis	2	1			1	2
Campylodiscus	1		1			1
Cocconeis	7	6	7	3	5	5
Cyclotella	6	2	2	2	2	4
Cymatopleura	3	1	2	1	2	2
Cymbella	16	7	5	2	13	5
Cymbellonitzschia	1		1			
Diatoma	1	1	1		1	
Diploneis	1				1	
Entomoneis	1	1	1	1	1	1
Epithemia	5	3		1	1	1
Eunotia	2	1				1
Fragilaria	16	12	7	7	12	12
Gomphoneis	1					1
Gomphonema	29	9	11	1	12	15

Table 5. continued

Genus	No. of Taxa/Genus	No. of Taxa/Genus/Lake LWO	LEO	CEN	SPI	SIL
Gyrosigma	4	1	2	1	1	
Melosira	6	4	6	3	3	3
Meridion	2	1				1
Navicula	60	27	28	5	28	29
Neidium	3		1	1		2
Nitzschia	28	16	18	6	15	15
Opephora	1	1			1	
Pinnularia	4		2	1	1	1
Rhoicosphenia	1	1	1	1	1	1
Rhopalodia	1				1	
Stephanodiscus	5	5	5	5	5	5
Surirella	6	2	2	2	2	4
Synedra	11	7	8	4	9	4
Total	248	124	125	57	135	126

Occasional (0) -- occurring 6 to 20 times in a count of approximately 600 valves,

Common (c) -- occurring 21 to 100 times in a count of approximately 600 valves,

Abundant (a) -- occurring 101 to 500 times in a count of approximately 600 valves,

Dominant (d) -- occurring more than 500 times in a count of approximately 600 valves.

The parameters considered in the autecology discussion for each species are described below:

Current Spectrum (after Hustedt, 1937 - 1938).

Limnobiontic: characteristic only of standing waters.

Limnophilous: characteristic of standing water but may be found in running water.

Indifferent: common in both flowing and standing water.

Rheophilous: characteristic of running water but may be found in standing water.

Rheobiontic: characteristic only of running water.

Temperature Spectrum (after Lowe, 1974):

Euthermal: warm-water forms usually occurring at temperature greater than 30°C.

Mesothermal: temperate-water forms, usually occurring between 15° and 30°C.

Oligothermal: cold-water forms, usually occurring between 0° and 15°C.

Stenothermal: occurring over a temperature range of no greater than 5°C.

Metathermal: occurring over a temperature range of from 5° to 15°C.

Eurythermal: occurring over a temperature range of 15°C or greater.

General Habitat:

Marine: characteristic of oceans and seas.

Estuary: characteristic of estuaries and brackish water habitats.

Lake: characteristic of large inland bodies of standing water.

Pond: characteristic of small bodies of standing water.

River: characteristic of larger streams.

Spring and Stream: characteristic of small streams.

Aerophilous: characteristic of non-submerged habitats.

Specific Habitat:

Euplanktonic: normally suspended in the water, distribution is current dependent.

Tychoplanktonic: normally associated with periphytic or terrestrial habitats but often suspended in the water.

Periphytic (aufwuchs, littoral): occurring on, but not penetrating, the substrate and submerged objects.

pH Spectrum (after Hustedt, 1937 - 1938):

Acidobiontic: occurring at pH values below 7, with optimal pH being below 5.5.

Acidophilous: occurring at pH values around 7, with optimal development below pH 7.

pH indifferent: optimal development around pH 7.

Alkaliphilous: occurring at pH values around 7, with optimal development at pH values above 7.

Alkalibiontic: occurring only in alkaline water.

Halobion Spectrum (after Kolbe, 1927):

Polyhalobous: occurring in salt concentrations above 40,000 mg/l.

Euhalobous: marine forms, occurring in salt concentrations of 30,000 to 40,000 mg/l.

Mesohalobous: brackish water forms, occurring in salt concentrations of 500 to 30,000 mg/l.

(alpha range - occurring in salt concentrations of 10,000 to 30,000 mg/l.)

(beta range - occurring in salt concentrations of 500 to 10,000 mg/l.)

Oligohalobous: Fresh water forms, occurring in salt concentrations of less than 500 mg/l.

(Halophilous - stimulated by small quantities of salt.)

(Indifferent - able to tolerate small amounts of salt.)

(Halophobous - unable to tolerate even small amounts of salt.)

Euryhalobous: occurring over a broad range of salt concentrations, often extending over two or more large spectral designations.

Nutrient Spectrum (after Smith, 1966):

Eutrophic: characteristic of water with high nutrient concentrations.

Mesotrophic: characteristic of water with moderate nutrient concentrations.

Oligotrophic: characteristic of water with low nutrient concentrations.

Dystrophic: characteristic of water rich in humic materials.

Saprobien Spectrum (after Kolkwitz and Marsson, 1908):

Polysaprobic: characteristic of the zone of degradation and putrefaction of organic pollutants, oxygen usually in low concentration or may be absent.

Mesosaprobic: characteristic of the zone where oxidation of the organic load is occurring.

(alpha range - range of heavier pollution, nitrogen is in the form of amino acids.

(beta range - range of lesser pollution, nitrogen is in the form of ammonia compounds.

Oligosaprobic: characteristic of the zone where oxidation of biodegradable compounds is complete, inorganic nutrient concentration is usually high.

Saprophilic: usually occurring in polluted waters, but may also occur in clean water habitats.

Saproxenous: Typically occurring in clean water habitats, but may also be found in polluted waters.

Saprophobic: characteristic of water which has not been exposed to pollutants.

Achnanthes affinis Grun. var. *affinis*

Plate: 11, Fig. 5.

Critical reference: Patrick and Reimer, 1966, p. 254, Pl. 16, Figs. 11-12.

Descriptors: Valve lanceolate, apices broad, obtusely rounded. Striae strongly radiate throughout, 30 in 10 μm, both valves. Length, 19 μm. Breadth, 3.2 μm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hustedt, 1930a; Hohn and Hellerman, 1963; Patrick and Reimer, 1966). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Hornung, 1959; Patrick and Reimer, 1966; Cholnoky, 1968). Alkalibiontic (Cholnoky, 1968). Oligohalobous indifferent (Schroeder, 1939). Oligohalobous (Simonsen, 1962). Seasonal maximum - winter (Hornung, 1959). Requires high oxygen concentration (Cholnoky, 1968).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Silver Lake Fen (Schobe et al., 1963). Drainage ditches (Lowe, 1970; Edwards, 1974).

Occurrence: Found only in Lake Okoboji, but always rare and never common (Table 6). No clear indication of periodicity or temperature preference.

Achnanthes clevei Grun. var. *clevei*

Plate: 11, Fig. 6, 7, and 12.

Critical reference: Patrick and Reimer, 1966, p. 267, Pl. 17, Figs. 21 - 22.

Descriptors: Valve lanceolate, apices obtusely rounded. Raphe valve - striae strongly radiate, alternately longer and shorter at the center of the valve. Pseudoraphe valve - striae radiate near apices, parallel at the center of the valve. Striae, 25 - 26 in 10 µm (RV); 15 in 10 µm, and coarsely punctate (PRV). Length, 12.6 - 15.5 µm. Breadth, 5.4 - 6.3 µm.

Ecology: Freshwater lakes (Hustedt, 1930a, 1937 - 1938; Jorgensen, 1948; Patrick and Reimer, 1966); streams and rivers (Hohn and Hellerman, 1963; Patrick and Reimer, 1966; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Hustedt, 1937 - 1938; Jorgensen, 1948; Foged, 1948). Alkaliphilous (Hustedt, 1937 - 1938; Foged, 1948, 1949, 1953, 1954; Patrick and Reimer, 1966). Eutrophic (Hustedt, 1930a, 1937 - 1938; Jorgensen, 1948). Oligohalobous indifferent (Hustedt, 1930a; Petersen, 1943; Foged, 1948, 1953, 1968). Saproxenous (Hustedt, 1957).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Arend's Kettle Hole (Collins, 1968).

Occurrence: This entity has been found in all the lakes, though always rare in the plankton (Table 7). It appears to be temperature indifferent (Figure 9), however, it was more abundant during early summer when temperatures were above 20°C.

Achnanthes clevei var. *rostrata* Hustedt

Plate: 11, Fig. 13.

Critical reference: Patrick and Reimer, 1966, p.

Table 6. Summary of distribution and relative abundance for *Achnanthes affinis* v. *affinis*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							r
Center Lake											
Spirit Lake											
East Okoboji											

Table 7. Summary of distribution and relative abundance for *Achnanthes clevei* v. *clevei*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake					r		r	r			
West Okoboji				r			r		r		
Center Lake				r							
Spirit Lake			r	r					r		
East Okoboji				o			r	r			

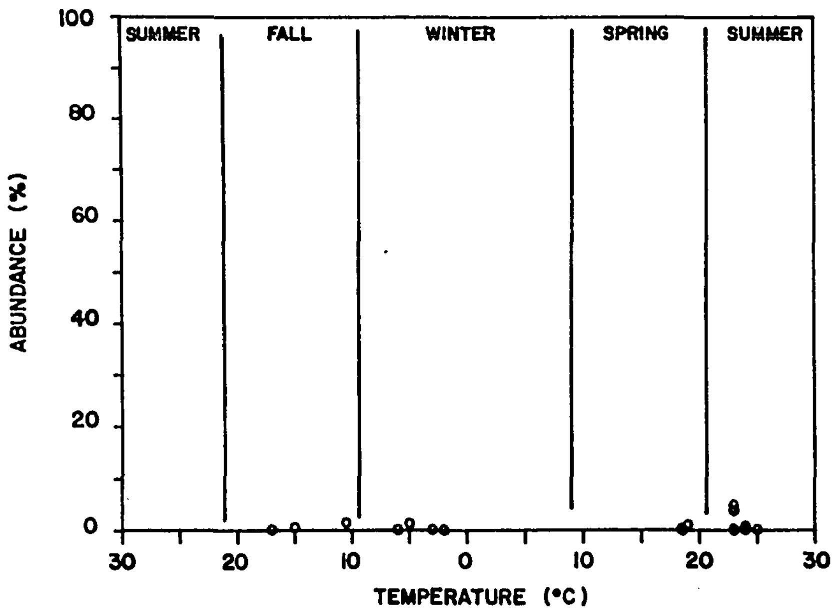

Figure 9. Abundance vs. temperature and season for populations of _Achnanthes_ _clevei_

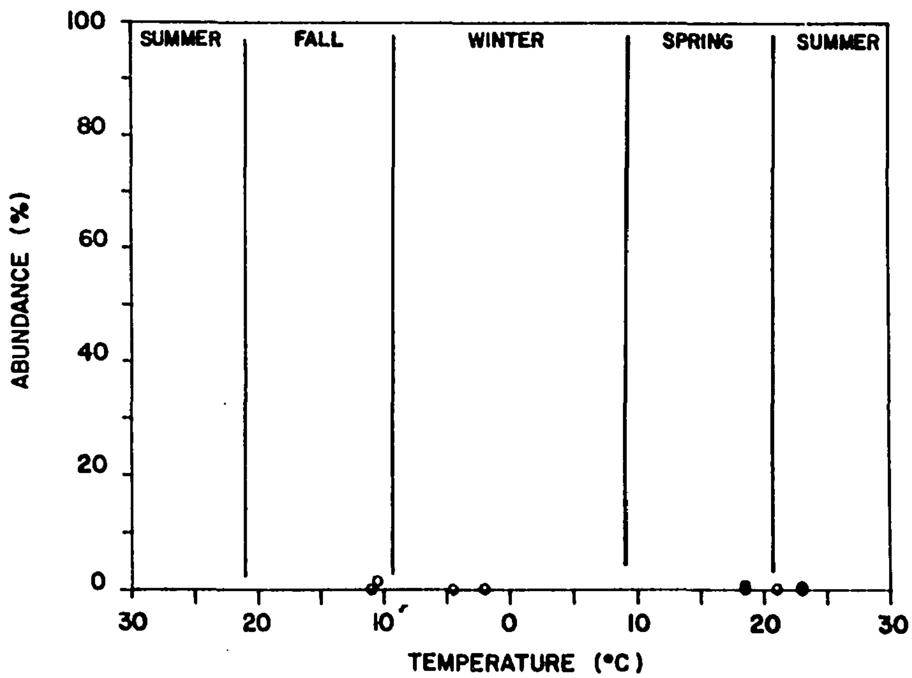

Figure 10. Abundance vs. temperature and season for populations of _Achnanthes_ _conspicua_

267, pl. 17, Figs. 23 - 24.

Descriptors: Valve lanceolate, with distinctly rostrate apices. Other characteristics as in the nominate variety. Striae, 25 - 26 in 10 µm (RV); 14 - 16 in 10 µm (PRV). Length, 18 - 19 µm. Breadth, 7 µm.

Ecology: Freshwater, periphytic (Hustedt, 1959b); euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963).

Occurrence: Less common than the nominate variety and collected from only two of the lakes sampled (Table 8). It has been reported from the periphyton (benthos) (Hosseini, 1979) and plankton (Stoermer, 1963a) of Lake West Okoboji. There is no clear indication of periodicity or optimum temperature.

Achnanthes conspicua A. Mayer var. *conspicua*

Plate: 11, Figs. 14 and 15.

Critical reference: Hustedt, 1959b, p. 387, Figs. 833, a - d.

Descriptors: Valve elliptical, apices obtusely rounded. Raphe valve - striae radiate near apices becoming parallel at the central area; central area narrow, rectangular. Pseudoraphe valve - features as on the raphe valve. Striae, 12 - 14 in 10 µm. Length, 6 - 14 µm. Breadth, 4 - 6 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Periphytic (Hustedt, 1959a); euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: A rare entity in the plankton (Table 9). It was present in samples from all of the lakes. No clear indication of periodicity or temperature preference (Figure 10).

Achnanthes exigua var. heterovalva Krasske

Plate: 11, Fig. 16.

Critical reference: Patrick and Reimer, 1966, p. 258, Pl. 16, Figs. 25-26.

Descriptors: Valve broadly linear, apices rostrate. Raphe valve with narrow axial area, broadening into a rectangular central area; distal raphe ends bent in opposite directions; striae slightly radiate throughout. Features of the pseudoraphe valve similar to the raphe valve; striae coarser than on the raphe valve. Striae, 30 in 10 µm (RV); 20 in 10 µm (PRV). Length, 10.5 µm. Breadth 5.4 µm.

Ecology: Freshwater, lakes (Hustedt, 1930a; Patrick

Table 8. Summary of distribution and relative abundance for <u>Achnanthes</u> <u>clevei</u> v. <u>rostrata</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r					r			
East Okoboji			r								

Table 9. Summary of distribution and relative abundance for <u>Achnanthes</u> <u>conspicua</u> v. <u>conspicua</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r				r				
West Okoboji				r							
Center Lake					r						
Spirit Lake			r				r	r	r		
East Okoboji				r					r		

and Reimer, 1966; Stoermer and Yang, 1969). Rivers (Hustedt, 1930a; Patrick and Reimer, 1966; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Manguin, 1952). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Manguin, 1952). Current indifferent (Foged, 1948, 1954). Eurythermal (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971); Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979); Spirit Lake (Krohn et al., 1974); Des Moines River (Drum, 1964); drainage ditches (Lowe, 1970); farm ponds (Ohl, 1965); subaerial habitats (Stoermer, 1962). Arend's Kettle Hole (Collins, 1968).

Occurrence: Rare, in a single sample from Center Lake (Table 10).

Achnanthes hauckiana Grun. var. *hauckiana*

Plate: 12, Fig. 1 and 2.

Critical reference: Patrick and Reimer, 1966, p. 267, pl. 17, Figs. 25 - 32.

Descriptors: Valve elliptical to elliptical - lanceolate. Apices obtusely rounded. Raphe valve - central area elliptical; striae coarse and radiate. Pseudoraphe valve - central area lacking; striae as in the raphe valve. Striae 11 in 10 µm. Length, 16 µm. Breadth, 7.5 µm.

Table 10. Summary of distribution and relative abundance for *Achnanthes exigua* v. *heterovalva*.

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake						r					
Spirit Lake											
East Okoboji											

Table 11. Summary of distribution and relative abundance for *Achnanthes hauckiana* v. *hauckiana*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				o	r						

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Brackish water (Patrick and Reimer, 1966). Euplanktonic (Stoermer and Yang, 1969). Euryhalobous (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Collins, 1968). Brewer's Creek (Edwards and Christensen, 1973). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Observed only in summer samples from Lake East Okoboji (Table 11). Uncommon. Mesothermal.

Achnanthes hauckiana var. *rostrata* Schulz

Plate: 12, Fig. 3 and 4.

Critical reference: Patrick and Reimer, 1966. p. 269, Pl. 17, Figs. 33 - 34.

Descriptors: Valve lanceolate, apices rostrate, obtusely rounded. Raphe valve - central area orbicular, formed by the regular shortening of the striae in the center of the valve; striae strongly radiate throughout. Pseudoraphe valve - central area lacking; striae are distinctly punctate and slightly radiate throughout. Striae, 12 in 10 μm on both valves. Length, 12.6 μm. Breadth, 5.4 μm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Brackish water

(Hustedt, 1959a). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: None.

Occurrence: This entity is uncommon in plankton samples (Table 12). It was observed only in summer collections from Silver Lake and Lake East Okoboji. Mesothermal.

Achnanthes lanceolata Breb. ex. Kutz. var. lanceolata

Plate: 12, Figs. 5 and 7.

Critical reference: Patrick and Reimer, 1966, p. 269, Pl. 18, Figs. 1 - 10.

Descriptors: Valve lanceolate with obtusely rounded apices, or elliptical. Raphe value, central area rectangular, not extending to the valve margins. Striae slightly radiate throughout. Pseudoraphe valve with a distinct horseshoe-shaped thickening on one side of the valve. Striae as on the raphe valve. Striae, 11 - 16 in 10 μm. Length, 10 - 14 μm. Breadth, 4.5 - 7.2 μm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hustedt, 1937 - 1938; Hornung, 1959; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Schroeder, 1939; Manguin, 1952; Hornung, 1959). Alkaliphilous; (Hustedt, 1937 - 1938; 1957; Cholnoky, 1968). Oligohalobous indifferent (Hustedt, 1937 - 1938; 1957). Rheophilous (Hornung, 1959;

Table 12. Summary of distribution and relative abundance for <u>Achnanthes</u> <u>hauckiana</u> v. <u>rostrata</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake					r						
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				o							

Table 13. Summary of distribution and relative abundance for <u>Achnanthes</u> <u>lanceolata</u> v. <u>lanceolata</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r	o	r	r	r	r	r	r	
West Okoboji				r		r	r		r		
Center Lake				r							
Spirit Lake			r		r						
East Okoboji			r	c	r			r	r		

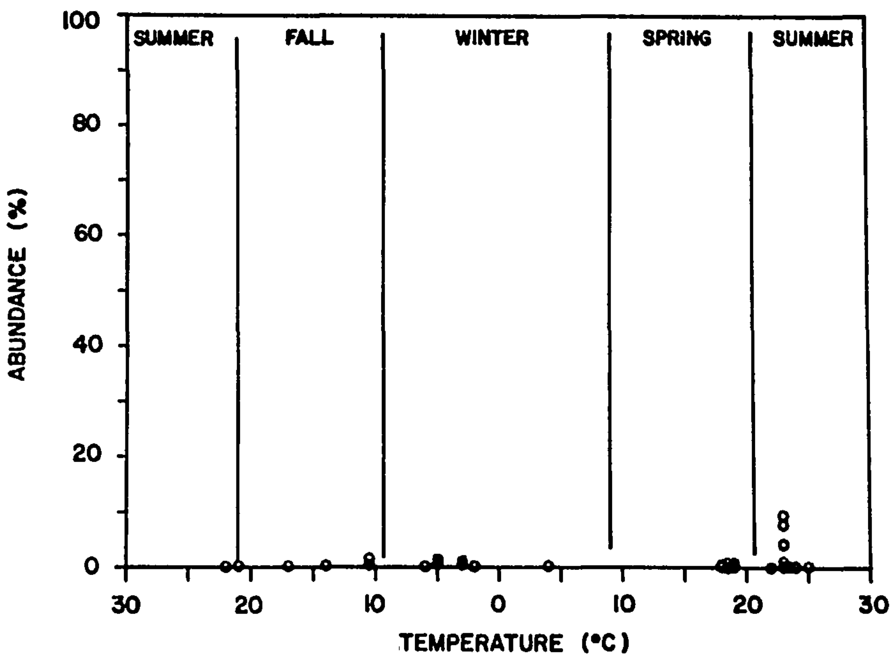

Figure 11. Abundance vs. temperature and season for populations of Achnanthes lanceolata

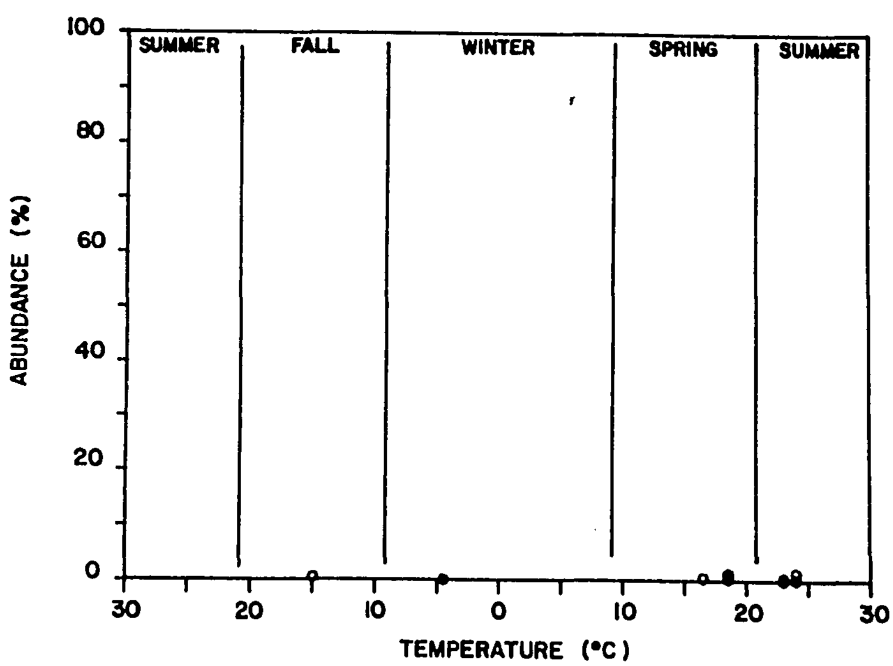

Figure 12. Abundance vs. temperature and season for populations of Achnanthes minutissima

Hustedt, 1957). Seasonal maximum - fall (Schroeder, 1939; Hornung, 1959).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Clear Lake (Begres, 1971). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Farm ponds (Ohl, 1965). Soil (Loescher, 1971). Cayler Prairie (Reimer, 1970). Spirit Lake (Krohn et al., 1974). Drainage ditches (Edwards, 1974). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Observed in collections from all the lakes, although typically uncommon (Table 13). A perennial species with a greater abundance during early summer. Temperature indifferent (Figure 11).

Achnanthes lanceolata var. *dubia* Grun.

Plate: 12, Fig. 8 and 9.

Critical reference: Patrick and Reimer, 1966, p. 271, pl. 18, Figs. 11 - 15.

Descriptors: Valve broadly lanceolate, with rostrate to sub-rostrate apices. Striae, 14 - 17 in 10 µm. Length, 9 - 15.8 µm. Breadth, 4.5 - 6.2 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoemer and Yang, 1969). Current indifferent (Foged, 1948); rheophilous (Patrick and Reimer, 1966). pH indifferent (Foged, 1958, 1964). Alkaliphilous (Foged, 1948, 1954; Patrick and Reimer, 1966). Halobion indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Soils (Reimer, 1970 - Cayler Prairie; Loescher, 1971). Arend's Kettle Hole (Collins, 1968).

Occurrence: This entity is rarer than the nominate variety (Table 14). It appears to be an autumnal species. Temperature indifferent.

Achnanthes lanceolata var. *omissa* Reimer

Plate: 12, Fig. 10 and 11.

Critical reference: Patrick and Reimer, p. 272, pl. 18, Figs. 16 - 17.

Descriptors: Striae, 16 in 10 µm. Length, 10.8 µm. Breadth, 6.3 µm. This variety resembles the smaller forms of the nominate variety. The striae are finer on the raphe valve and more strongly curved than the nominate variety.

Ecology: Freshwater lakes (Stoermer and Yang,

Table 14. Summary of distribution and relative abundance for <u>Achnanthes</u> <u>lanceolata</u> v. <u>dubia</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake					r		r				
West Okoboji											
Center Lake											
Spirit Lake								r			
East Okoboji											

Table 15. Summary of distribution and relative abundance for <u>Achnanthes</u> <u>lanceolata</u> v. <u>omissa</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r			r				r
Center Lake											
Spirit Lake											
East Okoboji	r										

1969); streams and rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Patrick and Reimer, 1966). Limnophilous (Patrick and Reimer, 1966).

<u>Previous reports from Iowa</u>: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Farm ponds (Ohl, 1965). Dutch Creek (Fee, 1967). Des Moines River (Drum, 1964). Skunk River (Beckert, 1977). Big Spirit Lake (Krohn et al., 1974).

<u>Occurrence</u>: This variety is uncommon in the plankton of two lakes (Table 15). No clear indication of periodicity or temperature preference.

<u>Achnanthes lapponica</u> v. <u>ninckei</u> (Guerm. and Mang.) Reimer comb.

<u>Plate</u>: 12, Fig. 12.

<u>Critical reference</u>: Patrick and Reimer, 1966, p. 259, Pl. 16, Figs. 29 - 30.

<u>Descriptors</u>: Central area unilateral on both valves. Reimer (Patrick and Reimer, 1966) states that he has not observed the nominate variety in this county. Striae, 25 in 10 µm. Length, 18.0 µm. Breadth, 6.3 µm.

<u>Ecology</u>: Insufficiently known (Patrick and Reimer, 1966). Freshwater, rivers (Collins and Kalinsky, 1977).

<u>Previous reports from Iowa</u>: None.

Occurrence: An extremely rare form observed only once in Spirit Lake (Table 16). No clear indication of periodicity or temperature preference.

Achnanthes linearis f. *curta* H.L. Sm.

Plate: 12, Fig. 13.

Critical reference: Patrick and Reimer, 1966, p. 252, Pl. 16, Figs. 13 - 14.

Descriptors: Typically smaller than the nominate variety. Striae more strongly radiate. Striae, 30 in 10 µm. Length, 9.0 µm. Breadth, 3.0 µm.

Ecology: Insufficiently known (Patrick and Reimer, 1966). Freshwater rivers (Collins and Kalinsky, 1977).

Previous reports from Iowa: None.

Occurrence: Rare form from the late spring plankton of Spirit Lake (Table 17). No clear indication of periodicity or temperature optimum.

Achnanthes minutissima Kutz. var. *minutissima*

Plate: 12, Fig. 14 and 15.

Critical Reference: Patrick and Reimer, 1966, p. 253, Pl. 16, Fig. 9 - 10.

Descriptors: Striae, 26 in 10 µm. Length, 10.8 µm. Breadth 3.2 µm.

Table 16. Summary of distribution and relative abundance for *Achnanthes lapponica* v. *ninckei*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake		r									
East Okoboji											

Table 17. Summary of distribution and relative abundance for *Achnanthes linearis* f. *curta*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Manguin, 1952). pH indifferent (Hustedt, 1937 - 1938; Jorgensen, 1948; Foged, 1948, 1953, 1964). Oligohalobous indifferent (Foged, 1948, 1953, 1954; Hustedt, 1957). Mesosaprobic (Budde, 1931; Fjerdingstadt, 1950) to oligosaprobic (Hustedt, 1957; Hornung, 1959). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Eurythermal (Hustedt, 1937 - 1938).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Drainage ditches (Lowe, 1970). Des Moines River (Drum, 1964). Skunk River (Roeder, 1976). Farm ponds (Ohl, 1965). Soil (Hayek and Hulbary, 1956). Subaerial habitats (Stoermer, 1962). Arend's Kettle Hole (Collins, 1968).

Occurrence: An uncommon entity in the plankton of all of the lakes (Table 18). It appears to be a perennial species. Temperature indifferent (Figure 12).

Achnanthes sp. 1

Plate: 12, Fig. 16.

Description: Length, 9.9 µm. Breadth, 4.5 µm. Striae, 14.

Table 18. Summary of distribution and relative abundance for <u>Achnanthes</u> <u>minutissima</u> v. <u>minutissima</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r								
West Okoboji				r							
Center Lake				r							r
Spirit Lake			o	r				r			
East Okoboji							r				

Table 19. Summary of distribution and relative abundance for <u>Achnanthes</u> sp. 1

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji		r						r			
Center Lake											
Spirit Lake				r				r			r
East Okoboji				r							

Occurrence: Rare in the plankton of the Region (Table 19). Observed in samples from lakes East and West Okoboji and Spirit Lake.

Achnanthes sp. 2.

Plate: 12, Fig. 17.

Description: Length, 12 µm. Breadth, 4.5 µm. Striae, 18 in 10 µm.

Occurrence: Rare in the plankton of Lake West Okoboji and Spirit Lake (Table 20).

Achnanthes sp. 3.

Plate: 12, Fig. 18.

Description: Length, 13.5 µm. Breadth, 6 µm. Striae, 13 in 10 µm.

Occurrence: Rare in a single plankton sample from Spirit Lake (Table 21).

Amphipleura pellucida (Kutz.) Kutz. var. *pellucida*

Plate: 14, Fig. 5.

Critical reference: Patrick and Reimer, 1966, p. 303, Pl. 21, Fig. 2.

Descriptors: Length, 70 µm. Breadth, 8 µm. Striae, >35 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Tychoplanktonic (Schroeder, 1939); periphytic (Manguin, 1952).

Table 20. Summary of distribution and relative abundance for *Achnanthes* sp. 2

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											r
Center Lake											
Spirit Lake									r		
East Okoboji											

Table 21. Summary of distribution and relative abundance for *Achnanthes* sp. 3

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

Alkaliphilous (Foged, 1948, 1954; Hustedt, 1957). Eutrophic (Hustedt, 1937-1938). Halobion indifferent (Foged, 1948, 1954; Manguin, 1952). Oligosaprobic to Beta-Mesosaprobic (Kolkwitz, 1914). Limnobiontic (Foged, 1948, 1954).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979) and Ventura Marsh (Begres, 1971). Des Moines River (Drum, 1964). Farm ponds (Ohl, 1965).

Occurrence: Very rare. Observed in a single plankton sample from Center Lake (Table 22).

Amphora ovalis Kutz. ovalis

Plate: 19, Fig. 4 and 8.

Critical reference: Patrick and Reimer, 1975, p. 68, Pl. 13, Figs. 1 - 2.

Descriptors: Central, dorsal striae smooth, not punctate except near the valve margin. Striae 11 in 10 µm. Length, 40 µm. Breadth, 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Periphytic (Hustedt, 1930 a, 1937 - 1938; Hornung, 1959). Alkaliphilous (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1953, 1968a). Oligohalobous indifferent (Foged, 1948, 1953, 1968b; Hustedt, 1957). Oligosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914; Fjergingstadt, 1950). Current indifferent (Foged, 1948,

Table 22. Summary of distribution and relative abundance for *Amphipleura pellucida* v. *pellucida*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											r
Spirit Lake											
East Okoboji											

Table 23. Summary of distribution and relative abundance for *Amphora ovalis* v. *ovalis*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r			r				O
West Okoboji					r	r	r				
Center Lake											
Spirit Lake											
East Okoboji											

1954) to limnophilous (Hornung, 1959).

Previous reports from Iowa: North Twin Lake (Kutkukn 1958). Lake West Okoboji (Collins, 1968: Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969; Starrett and Patrick, 1952). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965). Silver Lake Fen (Shobe et al., 1963). Subaerial habitats (Stoermer, 1962). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: A rare form observed during spring, summer and fall (Table 23) (Figure 13). Mesothermal, occurring at temperatures greater than 10° C.

Amphora ovalis var. affinis (Kutz.) V. H.

Plate: 19, Fig. 5.

Critical reference: Patrick and Reimer, 1975, p. 69, Pl. 13, Figs. 3 - 4.

Descriptors: Differs from the nominate variety by having dorsal striae interrupted by a blank space. Striae, 11 - 12 in 10 µm. Length, 40.0 µm. Breadth, 10.0 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellermen, 1963; Collins and Kalinsky, 1977). Characteristic of standing or flowing waters (Patrick and Reimer, 1975). Alkaliphilous (Patrick and Reimer, 1975).

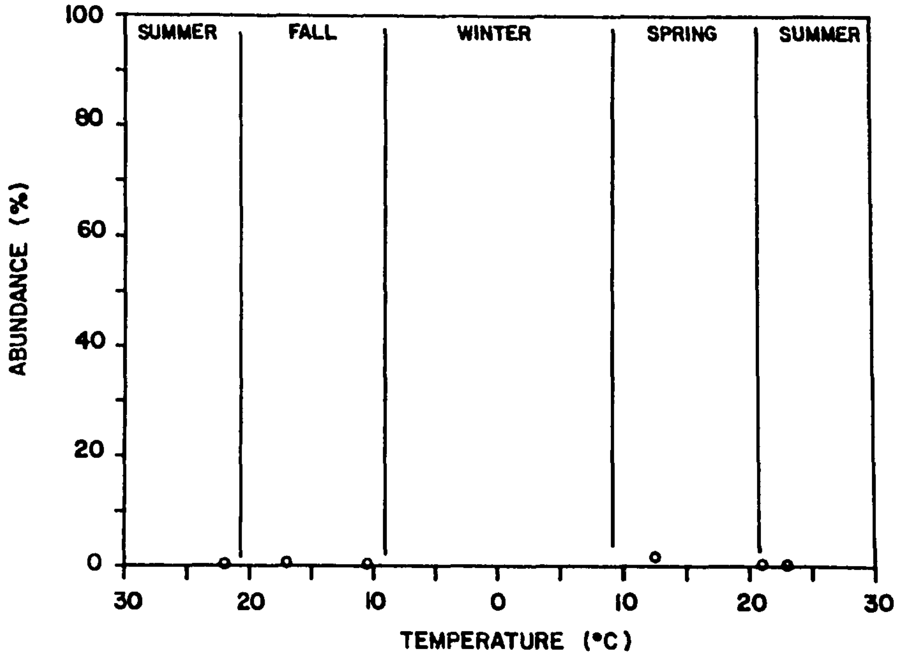

Figure 13. Abundance vs. temperature and season for populations of Amphora ovalis

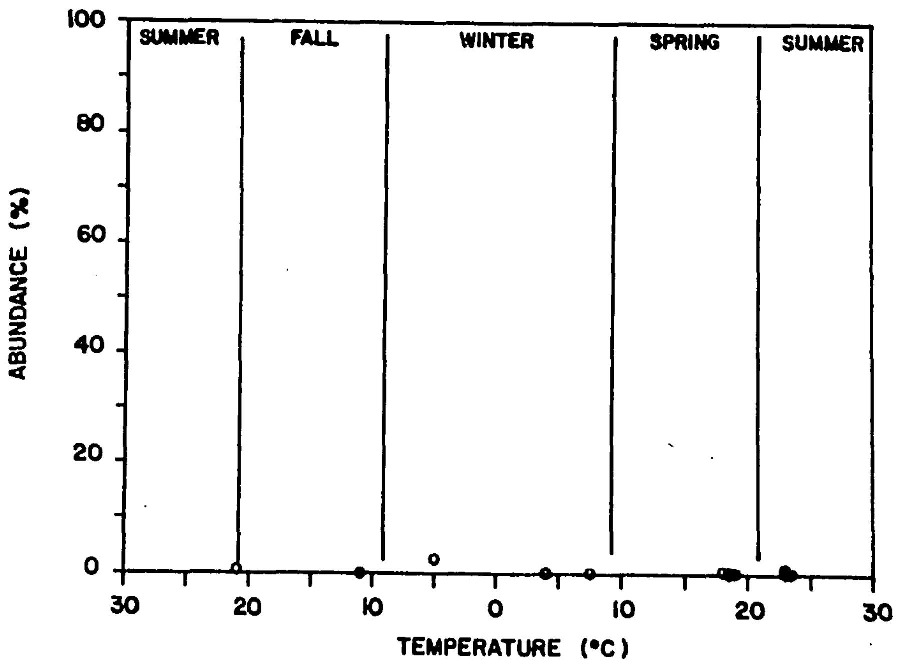

Figure 14. Abundance vs. temperature and season for populations of Amphora ovalis v. affinis

Table 24. Summary of distribution and relative abundance for <u>Amphora</u> <u>ovalis</u> v. <u>affinis</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r	r	r		r		r	
West Okoboji				r							r
Center Lake											
Spirit Lake			r				r				
East Okoboji				r							

Table 25. Summary of distribution and relative abundance for <u>Amphora</u> <u>ovalis</u> v. <u>pediculus</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r	r	r	r	r			
West Okoboji			r	r					r		r
Center Lake			r	r							
Spirit Lake			r				r	r	r		
East Okoboji		r	r	o		r		r	r		

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Lake West Okoboji (Collins, 1968). Drainage tiles (Edwards, 1974). Arend's Kettle Hole (Collins, 1968).

Occurrence: A rare entity but more common than the nominate variety in plankton collections (Table 24). A perennial species with no obvious temperature preference (Figure 14).

Amphora ovalis var. pediculus (Kutz.) V. H.

Plate: 19, Fig. 6.

Critical reference: Patrick and Reimer, 1975, p. 69, Pl. 13, Figs 5a - 6b.

Descriptors: Patrick and Reimer (1975) state that this species is most similar to var. affinis, differing only in striae number and size. Striae, 15 in 10 µm. Length, 23 µm. Breadth, 6 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hustedt, 1937 - 1938; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Hornung, 1959); epiphytic (Foged, 1948). Alkaliphilous (Hustedt, 1937 - 1938, 1957; Jorgensen, 1948; Foged, 1948, 1953, 1964). Oligohalobous indifferent (Petersen, 1943; Foged, 1948, 1953, 1954, 1968a; Hustedt, 1957). Mesosaprobic (Fjerdingstadt, 1950) to oligosaprobic (Hustedt, 1957). Current indifferent (Foged, 1948, 1954; Hornung, 1959).

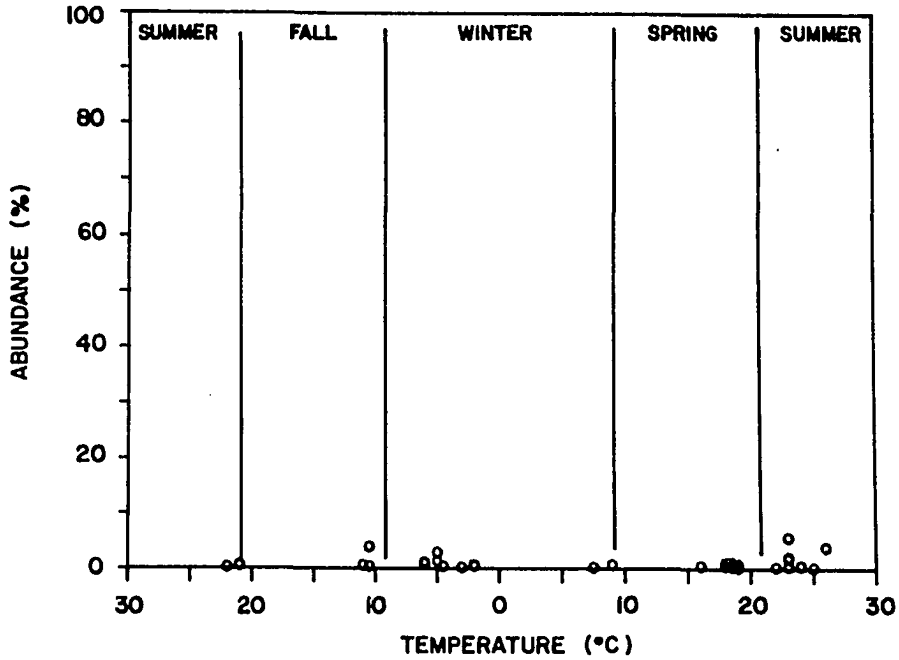

Figure 15. Abundance vs. temperature and season for populations of Amphora ovalis v. pediculus

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964). Skunk River (Roeder, 1976; Beckert, 1977). Farm ponds (Ohl, 1965). Drainage ditches (Lowe, 1970; Edwards, 1974). Dutch Creek (Fee, 1967). Subaerial habitats (Stoermer, 1962). Arend's Kettle Hole (Collins, 1968).

Occurrence: A perennial species observed in samples from all of the lakes (Table 25). Collected during all seasons. Temperature indifferent (Figure 15). More common in plankton collections than the nominate variety.

Amphora perpusilla (Grun.) Grun. var. perpusilla

Plate: 19, Fig. 7.

Critical reference: Patrick and Reimer, 1975, p. 70, Pl. 13, Figs. 8a - 11b.

Descriptors: Striae, punctate, 14 - 18 in 10 µm. Length, 12 - 26 µm. Breadth, 3.2 - 4 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Epilithic (Patrick and Reimer, 1975). Alkaliphilous (Patrick and Reimer, 1975).

Previous reports from Iowa: Lake East Okoboji (Volker, 1963). Farm Ponds (Ohl, 1965). Dutch Creek (Fee, 1967).

Occurrence: This entity is not uncommon in plankton collections from all of the lakes (Table 26). A perennial species observed during all seasons. Temperature indifferent (Figure 16).

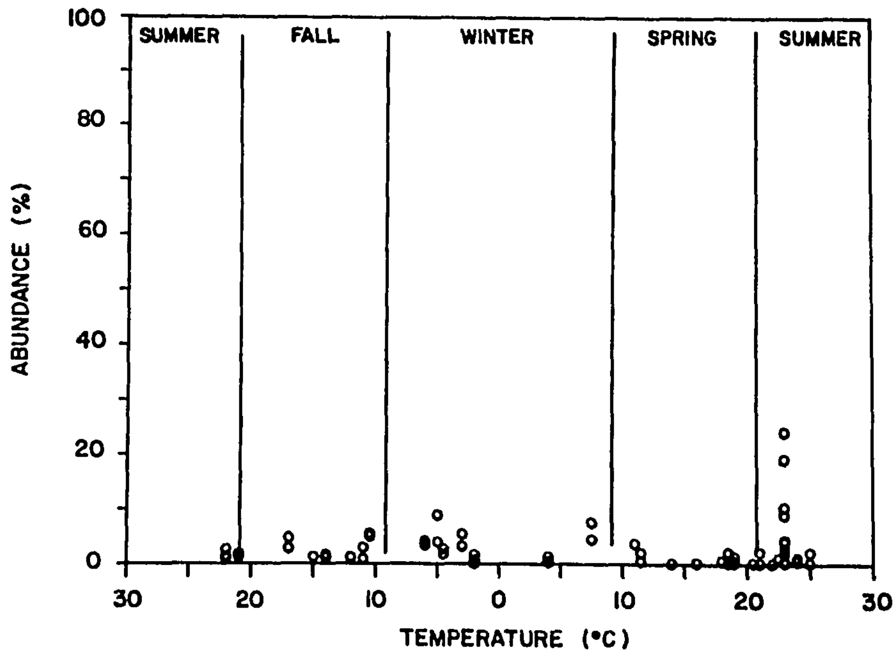

Figure 16. Abundance vs. temperature and season for populations of Amphora perpusilla

Amphora veneta Kutz. var. *veneta*

Plate: 19, Fig. 9.

Critical reference: Patrick and Reimer, 1975, p. 72, Pl. 14, Figs. 2 - 3.

Descriptors: Ventral striae appear as very short dashes. Striae, 20 - 26 in 10 µm. Length, 19 - 19.5 µm. Breadth, 3.5 - 4 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969); periphytic (Hustedt, 1930a). Alkaliphilous (Cholnoky, 1968; Foged, 1953, 1958). Oligohalobous indifferent (Foged, 1958; Hustedt, 1957). Euryhalobous (Budde, 1931; Kolbe, 1927). Limnobiontic (Foged, 1948). Current indifferent (Hustedt, 1957).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964; Fee and Drum, 1965). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Rare in the plankton from all the lakes (Table 27). No clear indication of temperature preference.

Table 26. Summary of distribution and relative abundance for <u>Amphora</u> <u>perpusilla</u> v. <u>perpusilla</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r	r	r	r	r	o	o		r	
West Okoboji		r	r	c	o	r	o		o	r	c
Center Lake				r	r						
Spirit Lake			o	r	r		o	o	r		r
East Okoboji			r	c		r	r	o	r		r

Table 27. Summary of distribution and relative abundance for <u>Amphora</u> <u>veneta</u> v. <u>veneta</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake										r	
West Okoboji					r						
Center Lake				r							
Spirit Lake			r	r	r	r	r				
East Okoboji				r				r			r

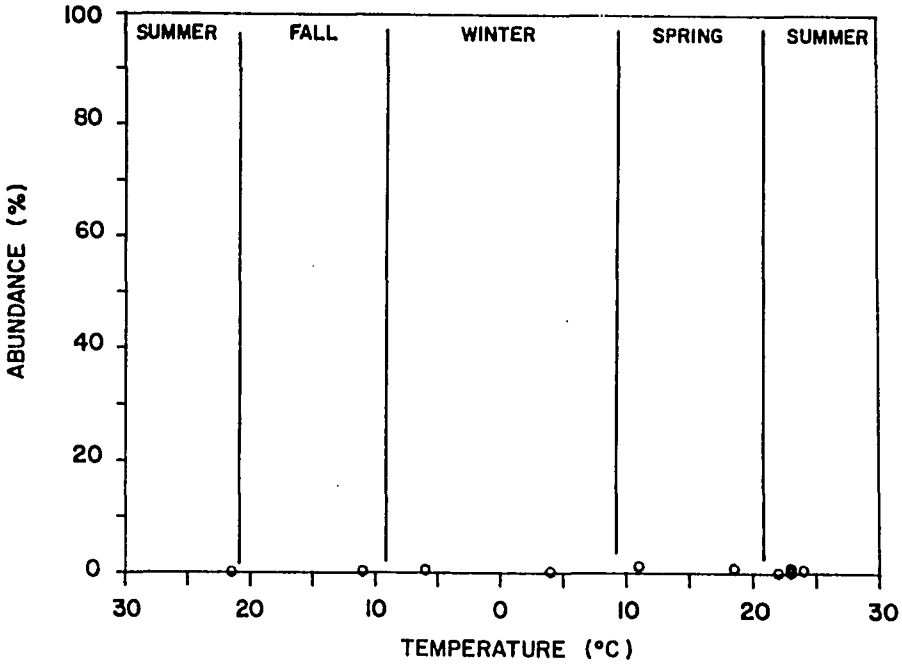

Figure 17. Abundance vs. temperature and season for populations of *Amphora veneta*

Perennial (Figure 17).

Anomoeoneis vitrea (Grun.) Ross comb. nov., var. *vitrea*

Plate: 12, Fig. 26.

Critical reference: Patrick and Reimer, 1966, p. 380, Pl. 33, Figs. 12 - 13.

Descriptors: Striae, 30 in 10 µm. Length, 18 µm. Breadth, 4.5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Periphytic (Hustedt, 1930a, 1937 - 1938); euplanktonic (Stoermer and Yang, 1969). pH indifferent to alkalibiontic (Foged, 1953, 1954, 1958; Hustedt, 1937 - 1938; Hustedt, 1957). Oligohalobous indifferent (Foged, 1953, 1954). Saproxenous (Hustedt, 1957). Current indifferent (Foged, 1954).

Previous reports from Iowa: Reported as *A. variablilis* (Ross) Reimer by Stoermer (1963a) from Lake West Okoboji. Lake West Okoboji (Collins, 1968). Clear Lake (Begres, 1971).

Occurrence: Extremely rare in the plankton of the Lake District (Table 28). Observed in only one sample from Spirit Lake. No clear indication of periodicity or temperature preference.

Asterionella formosa Hassall var. *formosa*

Plate: 9, Figs. 4 and 5.

Critical reference: Patrick and Reimer, 1966, p. 159, Pl. 9, Figs. 1 - 3.

Descriptors: Striae fine, 25 - 26 in 10 µm. Length 80 - 120 µm. Breadth 1 - 3 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Hustedt, 1957; Patrick and Reimer, 1966; Stoermer and Yang, 1969). Alkaliphilous (Cholnoky, 1968; Foged, 1968a; Hustedt, 1957). Nutrient, eutrophic (Hustedt, 1930a; Patrick and Reimer, 1966) to mesotrophic (Patrick and Reimer, 1966). Oligohalobous indifferent (Foged, 1948; Patrick and Reimer, 1966). Oligosaprobic (Fjerdingstadt, 1950; Hustedt, 1957; Kolkwitz, 1914) to beta-mesosaprobic (Fjerdingstadt, 1950; Kolkwitz, 1914). Limnobiontic (Foged, 1948) to limnophilous (Hustedt, 1957). Summer maximum (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Coralville Reservoir (Schmidt and Fee, 1967). Farm ponds (Ohl, 1965).

Occurrence: Common in the plankton of the Region (Table 29). Achieves its greatest abundance during the winter and spring. Oligothermal (cold - water form) although rare in

Table 28. Summary of distribution and relative abundance for *Anomoeoneis vitrea* v. *vitrea*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake								r			
East Okoboji											

Table 29. Summary of distribution and relative abundance for *Asterionella formosa* v. *formosa*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		o	r								
West Okoboji		a	c	r	r	o	c	o	a	o	
Center Lake			r						a	a	c
Spirit Lake			r	c					r	a	
East Okoboji		r					r		a	c	

the plankton during other seasons (Figure 18).

Caloneis bacillum (Grun.) Cleve var. bacillum

Plate: 12, Fig. 28.

Critical reference: Patrick and Reimer, 1966, p. 586, Pl. 54, Fig. 8.

Descriptors: Striae, 18 - 22 in 10 µm. Length, 12 - 29 µm. Breadth, 3.6 - 7.5 µm.

Ecology: Freshwater streams and rivers (Hustedt, 1930a; Foged, 1948; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Periphytic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948; Hustedt, 1957). Oligohalobous indifferent (Foged, 1948; Hustedt, 1957). Saproxenous (Hustedt, 1957). Rheophilous (Foged, 1948; Hornung, 1959).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Dutch Creek (Fee, 1967). Coralville Reservoir (Schmidt and Fee, 1967). Farm ponds (Ohl, 1965). Drainage ditches (Lowe, 1970). Silver Lake Fen (Shobe et al., 1963). Cayler Prairie (Reimer, 1970). Subaerial habitats (Stoermer, 1962). Arend's Kettle Hole (Collins, 1968).

Occurrence: Rare in the spring and summer plankton of

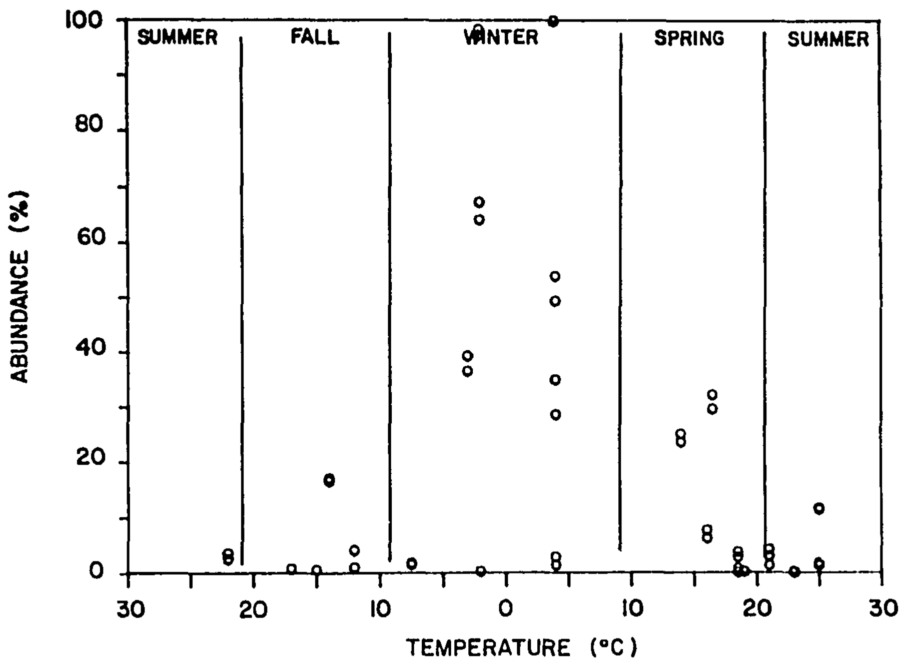

Figure 18. Abundance vs. temperature and season for populations of Asterionella formosa

Table 30. Summary of distribution and relative abundance for Caloneis bacillum v. bacillum

Lake	Apr 1979	May 1979	Jun 1979	Jul 1979	Aug 1979	Sep 1979	Oct 1979	Nov 1979	Jan 1980	Mar 1980	Apr 1980
Silver Lake			r		r						
West Okoboji					r						
Center Lake											
Spirit Lake											
East Okoboji											

Table 31. Summary of distribution and relative abundance for Caloneis clevei v. uruguayensis

Lake	Apr 1979	May 1979	Jun 1979	Jul 1979	Aug 1979	Sep 1979	Oct 1979	Nov 1979	Jan 1980	Mar 1980	Apr 1980
Silver Lake		r									
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Silver Lake and Lake West Okoboji (Table 30). No clear indication of periodicity or temperature preference.

Caloneis clevei var. *uruguayensis* Frenguelli

Plate: 12, Fig. 29.

Critical reference: Frenguelli, 1933, p. 130, Fig. 1a-b.

Descriptors: Striae, 22 in 10 µm. Length, 16.8 µm. Breadth, 5 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Skunk River (Beckert, 1977).

Occurrence: Rare, in a single plankton sample from Silver Lake (Table 31).

Caloneis ventricosa (Ehr.) Cl. var. *ventricosa*

Plate: 13, Fig. 2.

Critical reference: Patrick and Reimer, 1966, p. 583, Pl. 54, Fig. 3.

Descriptors: Length, 40 µm. Breadth, µm. Striae, 16 in 10 µm.

Ecology: Tolerant of a wide range of freshwater conditions (Patrick and Reimer, 1966). Lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Clear Lake and Ventura Marsh (Begres, 1971).

Lake West Okoboji (Stoermer, 1963a; Collins, 1968). North Twin Lake (Kutkukn, 1958). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965).

<u>Occurrence</u>: Rare. Observed in a single plankton sample from Spirit Lake (Table 32).

Table 32. Summary of distribution and relative abundance for *Caloneis ventricosa* v. *ventricosa*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake							r				
East Okoboji											

<u>Campylodiscus noricus</u> var. <u>hibernicus</u> (Ehr.) Grun.

<u>Plate</u>: 26, Fig. 7.

<u>Critical reference</u>: Hustedt, 1930a, p. 447, Fig. 872.

<u>Descriptors</u>: Wing-canals, 1 - 2 in 10 µm. Length, 52.2 µm. Breadth, 84 µm. Striae, fine.

<u>Ecology</u>: Freshwater lakes (Hustedt, 1930a; Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Sediments (Hustedt, 1930).

<u>Previous reports from Iowa</u>: Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Lake East Okoboji (Volker, 1963).

<u>Occurrence</u>: Rare in the fall and early winter plankton of Silver Lake and Lake East Okoboji (Table 33). No clear indication of periodicity or optimum temperature.

<u>Cocconeis diminuta</u> Pant. var. <u>diminuta</u>

<u>Plate</u>: 12, Fig. 19.

<u>Critical reference</u>: Hustedt, 1930a, p. 190, Fig. 265.

<u>Descriptors</u>: Striae, fine on raphe valve, 30 in 10 µm. Striae of pseudoraphe valve coarse, punctate, 12 in 10 µm. Length, 10 µm. Breadth 5 µm.

<u>Ecology</u>: Freshwater, streams and rivers (Hustedt, 1930a; Collins and Kalinsky, 1977); lakes (Hustedt, 1930a; Stoermer and Yang, 1969). Periphytic (Hustedt, 1937 - 1938; Schroeder, 1939); euplanktonic (Stoermer and Yang, 1969).

Table 33. Summary of distribution and relative abundance for *Campylodiscus noricus* v. *hibernicus*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake							r				
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji								r			

Table 34. Summary of distribution and relative abundance for *Cocconeis diminuta* v. *diminuta*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake						r					
West Okoboji				r	r		r				
Center Lake											
Spirit Lake											
East Okoboji				r							

Table 35. Summary of distribution and relative abundance for *Cocconeis disculus* v. *disculus*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r	r						
Center Lake											
Spirit Lake			r	r			r	r			
East Okoboji				r							

Alkalibiontic (Foged, 1948; Hustedt, 1957). Oligohalobous indifferent (Foged, 1948; 1954). Saproxenous (Hustedt, 1957). Current indifferent (Foged, 1948; 1954). Winter maximum (Schroeder, 1939).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Farm ponds (Ohl, 1965).

Occurrence: Rare in the summer and fall plankton of Silver Lake, Lake West Okoboji and Lake East Okoboji (Table 34). Eurythermal (Figure 19).

Cocconeis disculus (Schum.) Cl. var. disculus

Plate: 12, Fig. 20.

Critical reference: Patrick and Reimer, 1966, p. 239, Pl. 15, Figs. 1 - 2.

Descriptors: Striae finer on raphe valve, 22 in 10 um; pseudoraphe valve, 7 - 9 in 10 µm. Length, 21 - 24 µm. Breadth, 14 - 15 µm.

Ecology: Freshwater, springs (Patrick and Reimer, 1966); lakes (Patrick and Reimer, 1966; Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Drainage ditches (Edwards, 1974). Skunk River (Roeder, 1976).

Occurrence: Rare in the plankton of the Lake Region

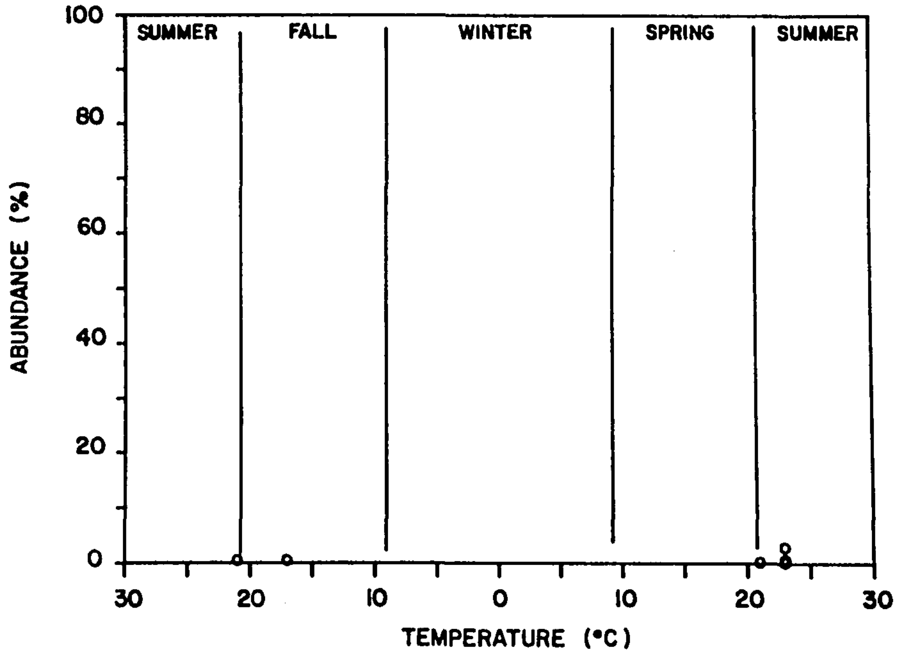

Figure 19. Abundance vs. temperature and season for populations of Cocconeis diminuta

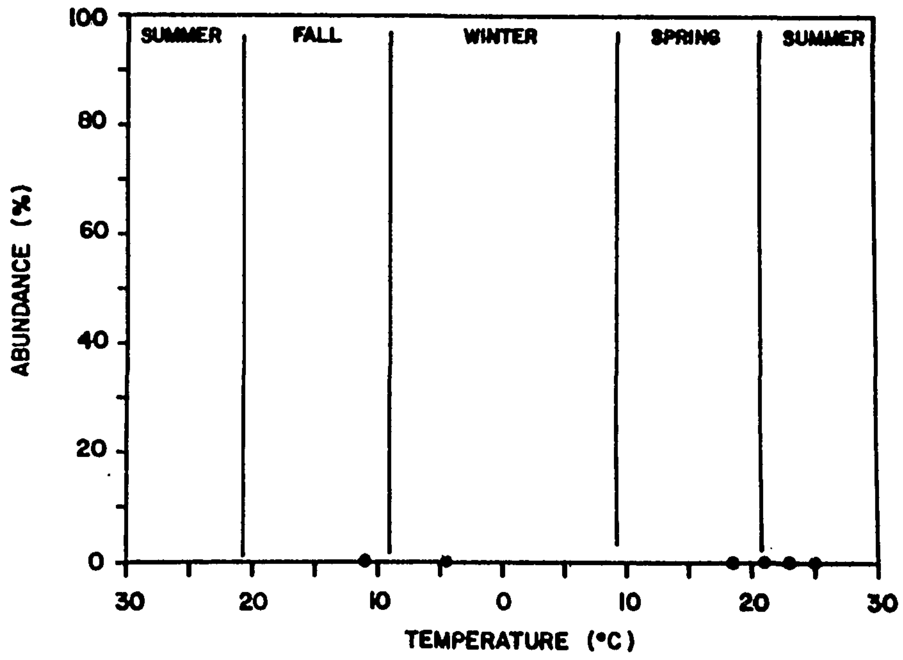

Figure 20. Abundance vs. temperature and season for populations of Cocconeis disculus

(Table 35). Appears to be a summer and fall form. Temperature indifferent (Figure 20).

Cocconeis hustedti Krasske var. hustedti

Plate: 12, Fig. 21.

Critical reference: Hustedt, 1959a, p. 361, Fig. 816.

Descriptors: Length, 15 µm. Breadth, 5 µm. Striae, 18 in 10 µm.

Ecology: Freshwater (Hustedt, 1959a). Insufficiently known.

Previous reports from Iowa: none.

Occurrence: Rare in the plankton of the Lake District (Table 36). Observed in a single sample from Lake East Okoboji.

Cocconeis pediculus Ehr. var. pediculus

Plate: 12, Figs. 22 and 23.

Critical reference: Patrick and Reimer, 1966, p. 240, Pl. 15, Figs. 3 - 4.

Descriptors: Striae, 15 - 20 in 10 µm. Length, 20 - 28 µm. Breadth, 11 - 22 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Epiphytic (Cholnoky, 1968; Niessen, 1956); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Cholnoky, 1968; Foged, 1948). Oligohalobous indifferent

Table 36. Summary of distribution and relative abundance for <u>Cocconeis</u> <u>hustedti</u> v. <u>hustedti</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				r							

Table 37. Summary of distribution and relative abundance for <u>Cocconeis</u> <u>pediculus</u> v. <u>pediculus</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r	r	r	r			r	
West Okoboji				o	r	r	r				
Center Lake											
Spirit Lake			r	r			r				
East Okoboji				r			r	r			

(Foged, 1948; Hustedt, 1957) but apparently tolerates some salt (Lowe, 1974). Saproxenous (Hustedt, 1937 - 1938) to beta - mesosaprobic (Fjerdingstadt, 1950; Kolkwitz, 1914). Current indifferent (Foged, 1948; Petersen, 1943).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins 1968; Hostetter and Stoermer, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Coralville Reservoir (Schmidt and Fee, 1967). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Skunk River (Roeder, 1976; Beckert, 1977). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965).

Occurrence: Rare in the plankton of the Lake Region (Table 37). Observed most commonly during the summer and fall.

Cocconeis placentula Ehr. var. *placentula*

Plate: 12, Fig. 24. Plate 13, Fig. 1.

Critical reference: Patrick and Reimer, 1966, p. 240, Pl. 15, Fig. 7.

Descriptors: Striae, 20 - 24 in 10 µm (RV); 24 - 26 in 10 µm (PR). Length, 25 - 31.5 µm. Breadth, 10 - 234.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1930a, 1937 - 1938; Hornung, 1959); epiphytic (Schroeder, 1939; Patrick and

Reimer, 1966); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948; 1953; 1968b; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1948, 1953, 1968a; Hustedt, 1937 - 1938, 1957). Saprophobic to alpha - mesosaprobic (Fjerdingstadt, 1950; Hustedt, 1957; Hornung, 1959). Current indifferent (Hustedt, 1937 - 1938; Foged, 1948, 1954). Seasonal maximum - fall (Schroeder, 1939; Hornung, 1959).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake East Okoboji (Volker, 1963). Lake West Okoboji (Stoermer, 1963a; Hostetter and Stoermer, 1968; Hosseini, 1979). Des Moines River (Drum, 1964). Silver Lake Fen (Shobe et al., 1963). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Rare in the plankton of all the lakes (Table 38). Most abundant during late fall, early winter, and late spring (Figure 21). A cold water form (oligothermal).

Cocconeis placentula var. *euglypta* (Ehr.) Cl.

Plate: 12, Fig. 25.

Critical reference: Patrick and Reimer, 1966, p. 241, Pl. 15, Fig. 8.

Descriptors: Striae, 18 - 20 in 10 µm, both valves. Length, 9 - 13.5 µm. Breadth, 5 - 8.1 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); Streams and rivers (Hohn and Hellerman, 1963; Collins and

Table 38. Summary of distribution and relative abundance for <u>Cocconeis</u> <u>placentula</u> v. <u>placentula</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r	o	r	o	o			
West Okoboji				r	r	r	r				r
Center Lake			r								
Spirit Lake			r		r		r	r	r	r	
East Okoboji		r	r	r	r		r	r	r	r	

Table 39. Summary of distribution and relative abundance for <u>Cocconeis</u> <u>placentula</u> v. <u>euglypta</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r	o	r	o	o			
West Okoboji				r	r	r	r	r			r
Center Lake				r							
Spirit Lake			r		r		r		r	r	
East Okoboji			r	r	r	r	r				r

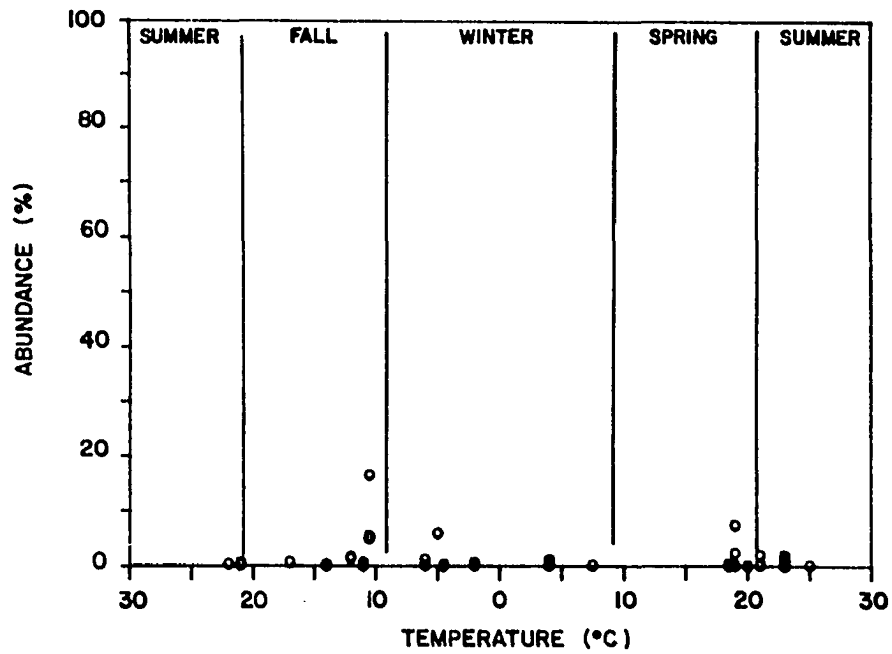

Figure 21. Abundance vs. temperature and season for populations of Cocconeis placentula

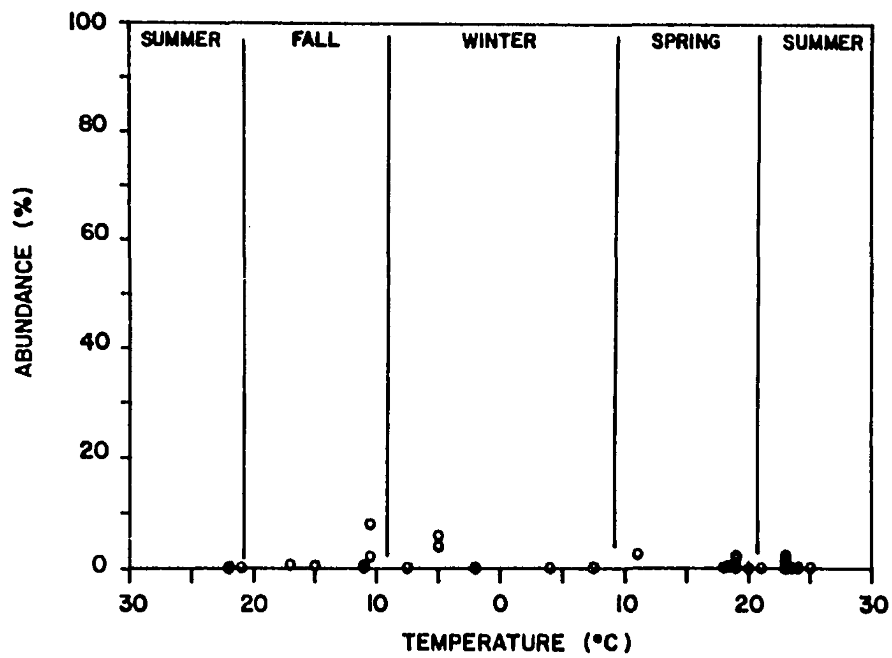

Figure 22. Abundance vs. temperature and season for populations of Cocconeis placentula v. euglypta

Kalinsky, 1977). Epiphytic (Schroeder, 1939; Patrick and Reimer, 1966); periphytic (Hustedt, 1930a, 1937 - 1938; Hornung, 1959); euplanktonic (Stoermer and Yang, 1969). Euthermal (Hustedt, 1930a). Alkaliphilous (Hustedt, 1937 - 1938; 1957; Foged, 1948, 1958; Patrick and Reimer, 1966). Oligahalobous indifferent (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1968a; Patrick and Reimer, 1966). Oligosaprobic (Hustedt, 1957). Current indifferent to rheophilous (Hustedt, 1937 - 1938; Foged, 1948; Hornung, 1959). Seasonal maximum - fall (Schroeder, 1939; Hornung, 1959).

Previous reports from Iowa: Lake East Okoboji (Volker, 1963). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964). Brewer's Creek (Edwards and Christensen, 1973). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965).

Occurrence: Observed in the plankton of all the lakes, but always rare (Table 39). Perennial, no clear pattern of periodicty or temperature optimum (Figure 22).

Cocconeis placentula var. lineata (Ehe.) V. H.

Plate: 12, Fig. 27.

Critical reference: Patrick and Reimer, 1966, p. 242, Pl. 15, Figs. 5 - 6.

Descriptors: Striae, 15 - 20 in 10 µm both valves. Length, 14.5 - 19 µm. Breadth, 9 - 13 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1930a, 1937 - 1938; Hornung, 1959); epiphytic (Schroeder, 1939; Patrick and Reimer, 1966); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1953; Hustedt, 1957; Hornung, 1959; Patrick and Reimer, 1966). Oligohalobous indifferent (Hustedt, 1930a, 1957; Foged, 1953, 1964; Patrick and Reimer, 1966). Oligosaprobic (Hustedt, 1957). Current indifferent to rheophilous (Hustedt, 1937 - 1938; Foged 1954; Hornung, 1959). Seasonal maximum - fall (Hornung, 1959).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Gudmundson, 1969). Skunk River (Beckert, 1977). Farm ponds (Ohl, 1965). Arend's Kettle Hole (Collins, 1968).

Occurrence: Perennial. Occurs in the plankton of all the lakes, but always rare (Table 40). No clear indication of a temperature optimum (Figure 23).

Cyclotella bodanica Eulenstein var. *bodanica*

Plate: 1, Fig. 8.

Critical reference: Hustedt, 1930a, P. 103, Fig. 76.

Descriptors. Diameter 20 µm. Striae, 14 in 10 µm along the valve margin.

Table 40. Summary of distribution and relative abundance for Cocconeis placentula v. lineata

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r	r	o	r	r	r			r
West Okoboji		r	r	r	r	o					r
Center Lake						r					
Spirit Lake			r		r		r	r	r		r
East Okoboji				r	r		r		r		r

Table 41. Summary of distribution and relative abundance for Cyclotella bodanica v. bodanica

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake									r		
East Okoboji											

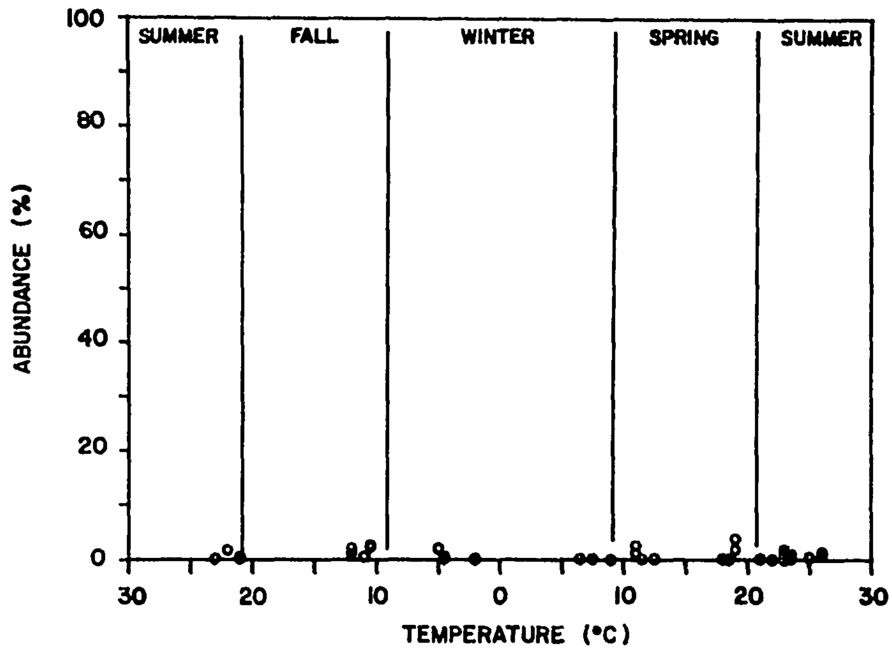

Figure 23. Abundance vs. temperature and season for populations of Cocconeis placentula v. lineata

Ecology: Freshwater, euplanktonic (Hustedt, 1957). Acidophilous (Cholnoky, 1968).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968).

Occurrence: Found in only one winter sample from Spirit Lake (Table 41). Oligothermal. No clear indication of periodicity.

Cyclotella compta (Ehr.) Kutz. var. compta

Plate: 1, Fig. 12.

Critical reference: Hustedt, 1930a, p. 103, Fig. 69.

Descriptors: Diameter, 10 - 12 µm. Striae, in 10 µm along the valve margin.

Ecology: Freshwater lakes (Hustedt, 1949; Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Hustedt, 1930a, 1937 - 1938; Raabe, 1951; Foged, 1953; Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1949, 1964; Hustedt, 1957). Oligohalobous indifferent (Foged, 1948, 1954; Petersen, 1943). Saproxenous to alpha - mesosaprobic (Kolkwitz and Marsson, 1908; Cupp, 1943; Hustedt, 1957). Current indifferent to limnophilous (Hustedt, 1930a; Foged, 1948, 1953).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Des Moines River

Table 42. Summary of distribution and relative abundance for Cyclotella compta v. compta

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake					r						
West Okoboji											
Center Lake					r						
Spirit Lake											
East Okoboji					r				r		

Table 43. Summary of distribution and relative abundance for Cyclotella meneghiniana v. meneghiniana

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r		r	r	r	r	r	r	r	
West Okoboji					r		r				
Center Lake		r									
Spirit Lake				r							
East Okoboji							r				

(Gudmundson, 1969).

Occurrence: Rare in the plankton of the Lake District (Table 42). No clear indication of periodicity or temperature preference.

Cyclotella meneghiniana Kutz. var. meneghiniana

Plate: 2, Fig. 1 and 5.

Critical reference: Hustedt, 1930a, p. 100, Fig. 67.

Descriptors: Diameter, 9 - 13 µm. Striae, in 10 µm along the valve margin.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Jorgensen, 1948; Cholnoky, 1968; Stoermer and Yang, 1969); periphytic (Hustedt, 1930a; Manguin, 1952); tychoplanktonic (Hustedt, 1930a; Manguin, 1952). Alkaliphilous (Foged, 1948, 1954; Hustedt, 1957; Cholnoky, 1968). Halophilous (Budde, 1931; Foged, 1948, 1954; Hustedt, 1930a, 1949, 1957). Alpha-mesosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914; Schroeder, 1939; Cupp, 1943). Current indifferent (Hustedt, 1930a; Foged, 1948). Seasonal maximum - fall (Raabe, 1951).

Previous reports from Iowa: Clear Lake (Begres, 1971). Spirit Lake (Krohn et al., 1974). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and

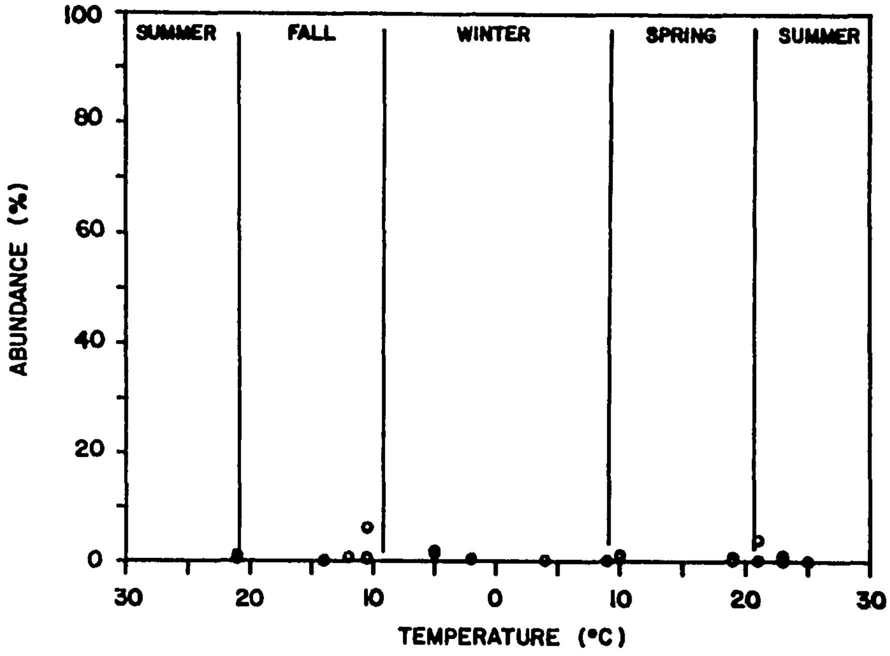

Figure 24. Abundance vs. temperature and season for populations of *Cyclotella meneghinian*

Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Coralville Reservoir (Schmidt and Fee, 1967). Drainage ditches (Edwards, 1974). Farm ponds (Ohl, 1965).

Occurrence: Rare in the plankton of all the lakes (Table 43). A perennial species which appears to be temperature indifferent (Figure 24).

Cyclotella michiganiana Skv. var. *michiganiana*

Plate: 1, Fig. 9 and 10.

Critical reference: Skvortzow, 1938, Pl. 1, Figs. 3, 10, 18.

Descriptors: Diameter, 5 - 10 µm. Spines scarcely discernible around the margins of the valve.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Mesotrophic (Stoermer and Yang, 1970; Holland and Beeton, 1972).

Previous reports from Iowa: None.

Occurrence: Most frequently encountered in collections from Silver Lake, but usually rare (Table 44). Also observed in Spirit Lake and Lake West Okoboji. Perennial species, no clear indication of periodicity or optimum temperature (Figure 25).

Table 44. Summary of distribution and relative abundance for <u>Cyclotella michiganiana</u> v. <u>michiganiana</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		c	r		r	r					
West Okoboji						r	r				
Center Lake											
Spirit Lake				r	r						
East Okoboji											

Table 45. Summary of distribution and relative abundance for <u>Cyclotella stelligera</u> v. <u>stelligera</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r				r					
West Okoboji											
Center Lake											
Spirit Lake									r		
East Okoboji											

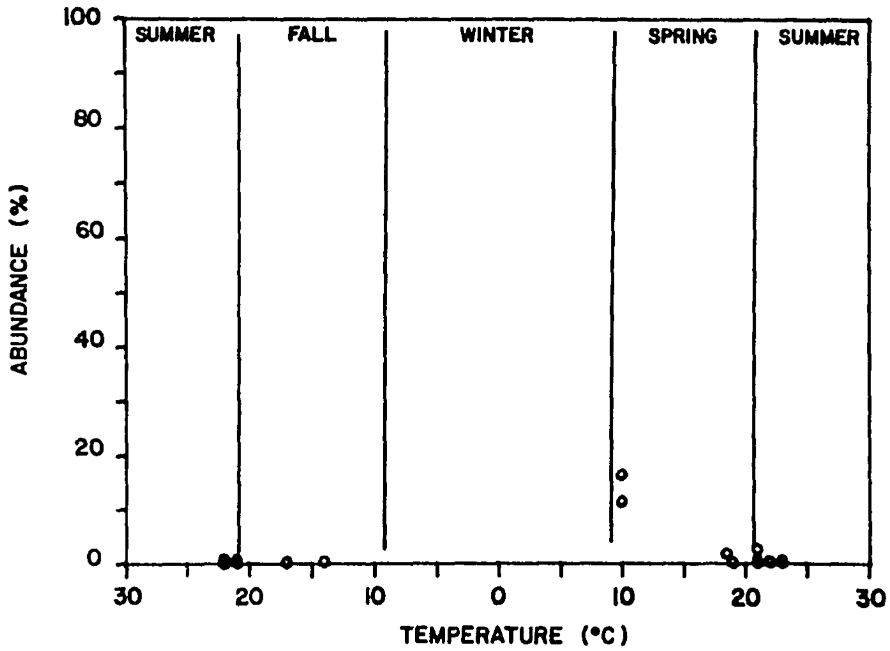

Figure 25. Abundance vs. temperature and season for populations of Cyclotella michiganiana

<u>Cyclotella stelligera</u> (Cleve and Grun.) V. H. var. <u>stelligera</u>

<u>Plate</u>: 1, Fig. 14.

<u>Critical reference</u>: Hustedt, 1930a, p. 100, Fig. 65.

<u>Descriptors</u>: Diameter, 20 µm. Striae, 7 in 10 µm along the valve margin.

<u>Ecology</u>: Freshwater, lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1930a; Manguin, 1952); tychoplanktonic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Schroeder, 1939; Cholnoky, 1968) to pH indifferent (Hustedt, 1957; Foged, 1954, 1958). Eutrophic (Cholnoky, 1968). Oligohalobous indifferent (Schroeder, 1939; Foged, 1948, 1958, 1968a). Saprophobic (Hustedt, 1957). Limnobiontic (Foged, 1948, 1954). Seasonal maximum - fall (Schroeder, 1939).

<u>Previous reports from Iowa</u>: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974).

<u>Occurrence</u>: A rare entity in the plankton of Silver

Lake and Spirit Lake (Table 45). No clear indication of periodicity or thermal optimum.

<u>Cyclotella striata</u> (Kutz.) Grun. var. <u>striata</u>

<u>Plate</u>: 1, Figs. 11 and 13.

<u>Critical reference</u>: Hustedt, 1930a, p. 101, fig. 71.

<u>Descriptors</u>: Cells 8 - 12 µm in diameter. Spines, 8 - 10 in 10 µm.

<u>Ecology</u>: pH indifferent (Hustedt, 1957) to alkaliphilous (Foged, 1948). Euhalobous (Hustedt, 1930a; Foged, 1964); mesohalobous (Hustedt, 1930a; Foged, 1948; Cholnoky, 1968); euryhalobous (Foged, 1948).

<u>Previous reports from Iowa</u>: Lake West Okoboji, sediment cores (Collins, 1968). Des Moines River (Drum, 1964).

<u>Occurrence</u>: Rare in the plankton of both Center Lake and Lake East Okoboji (Table 46). No clear indication of periodicity.

<u>Cymatopleura cochlea</u> J. Brun. var. <u>cochlea</u>

<u>Plate</u>: 25, Fig. 2.

<u>Critical reference</u>: Fricke and Hustedt, 1911, in A. Schmidt, 1874 - 1959, Pl. 276, Figs. 4 - 6.

<u>Descriptors</u>: Length, 78 µm. Breadth, 44.2 µm.

<u>Ecology</u>: Freshwater, lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Table 46. Summary of distribution and relative abundance for *Cyclotella striata* v. *striata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 47. Summary of distribution and relative abundance for *Cymatopleura cochlea* v. *cochlea*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r		r	r		r	r		r	
West Okoboji											
Center Lake											
Spirit Lake				r							
East Okoboji				r		r		r			

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake East Okoboji (Volker, 1963). Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964). Dutch Creek (Fee, 1967). Skunk River (Roeder, 1976; Beckert, 1977). Drainage ditches (Edwards, 1974). Farm ponds (Ohl, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: A perennial species, rare in the plankton of the Lake District (Table 47). Temperature indifferent. Greatest abundance observed during the summer and fall.

Cymatopleura elliptica (Breb.) Wm. Smith var. *elliptica*

Plate: 24, Fig. 6.

Critical reference: Hustedt, 1930a, p. 426, Fig. 825.

Descriptors: Striae fine, 17 in 10 µm. Length, 114 µm. Breadth, 61 µm. Keel canals, 4 in 10 µm.

Ecology: Freshwater, lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Spirit Lake (Krohn et al., 1974). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964). Skunk River (Beckert, 1977). Farm ponds (Ohl, 1965). North Twin Lake (Kutkukn, 1958).

Occurrence: Observed in a single summer plankton sample from Silver Lake (Table 48). Rare form, with no clear

Table 48. Summary of distribution and relative abundance for *Cymatopleura elliptica* v. *elliptica*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake				r							
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 49. Summary of distribution and relative abundance for *Cymatopleura solea* v. *solea*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		r	r	r			r				
West Okoboji				r						r	
Center Lake		r	r		r	r					r
Spirit Lake			r						r		
East Okoboji			r	r	r			r			

indication of periodicity or thermal optimum.

Cymatopleura solea (Breb.) Wm. Smith var. solea

Plate: 24, Fig. 2.

Critical reference: Hustedt, 1930a, p. 425, Fig. 823.

Descriptors: Length, 45 - 110 µm. Breadth, 17 - 30 µm. Keel canals, 8 in 10 µm.

Ecology: Freshwater, lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Kolkwitz, 1914; Hustedt, 1937 - 1938; Scheele, 1952); tychoplanktonic (Scheele, 1952); euplanktonic (Stoermer and Yang, 1969). Oligothermal (Cholnoky, 1968). Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1964, 1968a; Hustedt, 1957). Eutrophic (Bock, 1952). Oligohalobous indifferent (Petersen, 1943; Foged, 1948, 1954, 1968a; Hustedt, 1957). Oligosaprobic (Kolkwitz, 1914; Kolbe, 1927; Kolkwitz and Marsson, 1908) to beta - mesosaprobic (Schroeder, 1939; Fjerdingstadt, 1950). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Seasonal maximum - fall (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976, Beckert, 1977). Dutch Creek (Fee, 1967). Spirit Lake (Krohn et al., 1974).

Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: A perennial species, rare in the plankton of all the lakes (Table 49). Temperature indifferent (Figure 26).

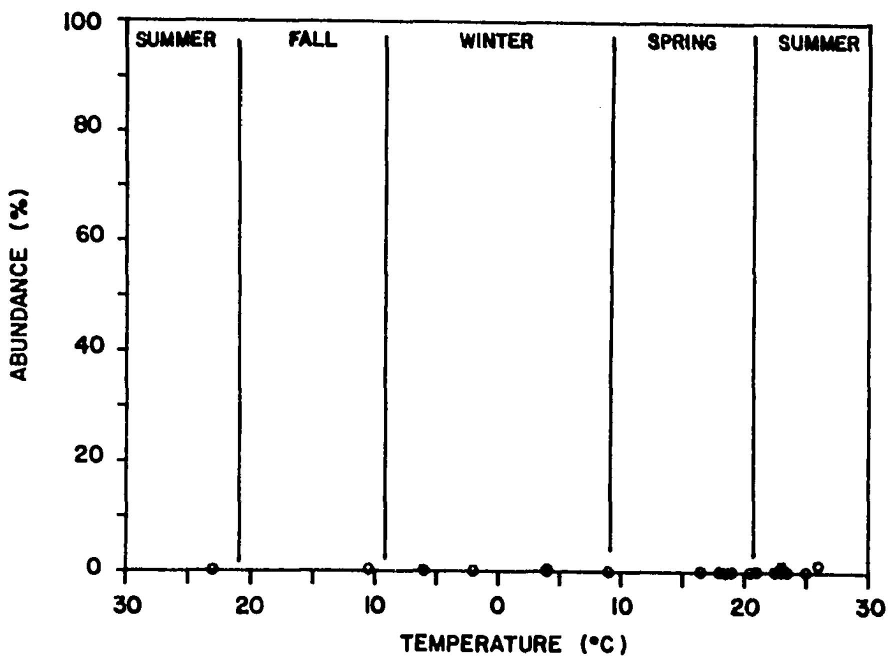

Figure 26. Abundance vs. temperature and season for populations of *Cymatopleura solea*

Cymbella affinis Kutz. var. *affinis*

Plate: 19, Fig. 11.

Critical reference: Patrick and Reimer, 1975, p. 57, Pl. 10, Fig. 7.

Descriptors: Striae, 9 - 11 in 10 µm. Length, 25 - 30 µm. Breadth, 8 - 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1953, 1964; Hustedt, 1957; Cholnoky, 1968) to alkalibiontic (Jorgensen, 1948; Foged, 1948, 1949, 1954). Oligohalobous indifferent (Hustedt, 1957; Foged, 1948, 1953, 1968a; Merilainen, 1967). Saprophobic (Blum, 1957; Hustedt, 1957) to oligosaprobic (Hustedt, 1957). Current indifferent (Foged, 1948, 1954; Hustedt, 1937 - 1938; 1957). Seasonal maximum - summer (Blum, 1957).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Des Moines river (Drum, 1964). Farm ponds (Ohl, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Observed only in Spirit Lake (Table 50). A rare form with no clear indication of periodicity or preferred temperature.

Cymbella aspersa (Ehr.) Heribaud var. *aspersa*

Plate: 19, Figs. 10, 12, and 13.

Critical reference: Patrick and Reimer, 1975, p. 53,

Table 50. Summary of distribution and relative abundance for <u>Cymbella affinis</u> v. <u>affinis</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

Table 51. Summary of distribution and relative abundance for <u>Cymbella aspersa</u> v. <u>aspersa</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											r
East Okoboji											

Pl. 10, Fig. 2.

Descriptors: Striae, 8 in 10 µm. Length, 162 µm. Breadth 35 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938); euplanktonic (Stoermer and Yang, 1969). Mesothermal (Bock, 1952) to metathermal (Bock, 1952). Alkaliphilous (Hustedt, 1957; Foged, 1948, 1953, 1968a). Oligohalobous indifferent (Kolbe, 1927; Hustedt, 1957; Foged, 1948, 1953, 1954). Oligosaprobic (Hustedt, 1957). Current indifferent (Foged, 1948, 1954). Seasonal maximum, spring (Bock, 1952).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Des Moines River (Gudmundson, 1969). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Rare, in a single plankton sample from Spirit Lake (Table 51).

Cymbella cistula (Ehr.) Kirchn. var. *cistula*

Plate: 20, Fig. 1.

Critical reference: Patrick and Reimer, 1975, p. 62, Pl. 11, Figs. 3 and 4.

Descriptors: Striae, 8 - 10 in 10 µm. Length, 60 - 126 µm. Breadth, 14 - 23 µm.

Ecology: Freshwater lakes (Raabe, 1951; Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1954, 1968a; Hustedt, 1937 - 1938, 1957; Merilainen, 1967; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Hustedt, 1957). Oligosaprobic (Kolkwitz and Marsson, 1908; Hustedt, 1957). Limnophilous (Foged, 1948, 1954) to limnobiontic (Hornung, 1959).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake East Okoboji (Volker, 1963). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: A rare entity in the Lake District (Table 52). It appears to be a spring form. The temperature optimum is uncertain (Figure 27).

Cymbella cuspidata Kutz. var. *cuspidata*

Plate: 20, Fig. 2.

Critical reference: Patrick and Reimer, 1975, p. 39,

Table 52. Summary of distribution and relative abundance for *Cymbella cistula* v. *cistula*

Lake	Apr 1979	May 1979	Jun 1979	Jul 1979	Aug 1979	Sep 1979	Oct 1979	Nov 1979	Jan 1980	Mar 1980	Apr 1980
Silver Lake		r		r							
West Okoboji				r							
Center Lake											
Spirit Lake		r	r					r			
East Okoboji											

Table 53. Summary of distribution and relative abundance for *Cymbella cuspidata* v. *cuspidata*

Lake	Apr 1979	May 1979	Jun 1979	Jul 1979	Aug 1979	Sep 1979	Oct 1979	Nov 1979	Jan 1980	Mar 1980	Apr 1980
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

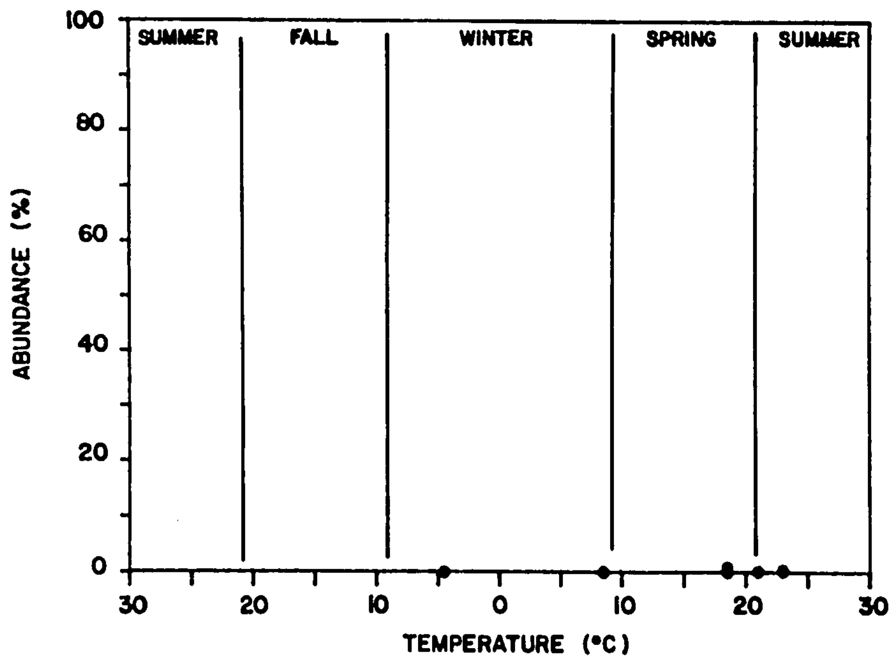

Figure 27. Abundance vs. temperature and season for populations of _Cymbella cistula_

Pl. 6, Figs. 2 - 3.

Descriptors: Striae, 12 in 10 µm, radiate throughout. Length, 20.7 µm. Breadth, 8.6 µm.

Ecology: Freshwater rivers (Hohn and Hellerman, 1963); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Drainage ditches (Lowe, 1970). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Rare in a single spring plankton sample from Spirit Lake (Table 53). Temperature optimum uncertain.

Cymbella cymbiformis Ag. var. *cymbiformis*

Plate: 20, Fig. 4.

Critical reference: Patrick and Reimer, 1975, p. 54, Pl. 10, Figs 3 - 4.

Descriptors: Striae, 9 - 11 in 10 µm, slightly radiate. Length, 27 - 40 µm. Breadth, 8 - 10 µm.

Ecology: Principally a lake form (Patrick and Reimer, 1975). Few reports from streams and rivers.

Previous reports from Iowa: None. Patrick and Reimer (1975) indicate that the U.S. distribution for this species includes the Plains States.

Occurrence: Observed only in Center Lake and Spirit Lake (Table 54). Rare, with no clear indication of

Table 54. Summary of distribution and relative abundance for <u>Cymbella</u> <u>cymbiformis</u> v. <u>cymbiformis</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake				r		r					
Spirit Lake			r					r			r
East Okoboji											

Table 55. Summary of distribution and relative abundance for <u>Cymbella</u> <u>lanceolata</u> v. <u>lanceolata</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake							r				
East Okoboji											

periodicity or temperature preference.

Cymbella lanceolata (Ag.) Ag. var. lanceolata

Plate: 20, Fig. 5.

Critical reference: Patrick and Reimer, 1975, p. 52, Pl. 10, Fig. 1.

Descriptors: Striae 9 in 10 µm, slightly radiate at the distal ends. Length, 114 - 126 µm. Breadth, 23 - 24 µm.

Ecology: Most common in shallow water littoral habitats, periphytic (Patrick and Reimer, 1975); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Patrick and Reimer, 1975). Halophobous (Patrick and Reimer, 1975).

Previous reports from Iowa: Lake West Okoboji (Hosseini, 1979).

Occurrence: Rare in plankton samples from Lake West Okoboji and Spirit Lake (Table 55). The seasonal periodicity and optimum temperature are unknown.

Cymbella mexicana (Ehr.) Cleve var. mexicana

Plate: 20, Fig. 3 and 7.

Critical reference: Patrick and Reimer, 1975, p. 59, Pl. 12, Figs. 1 - 2.

Descriptors: Striae, 6 - 7 in 10 µm, radiate. Length, 91 - 111 µm. Breadth, 26 - 36 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Most often reported from hard water, alkalaphilous (Patrick and Reimer, 1975). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Drainage ditches (Lowe, 1970). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Observed in the plankton of all lakes but Center Lake (Table 56). Always rare, occurs during the late fall and early spring. No clear pattern of temperature preference (Figure 28).

Cymbella microcephala Grun. var. *microcephala*

Plate: 20, Fig. 9.

Critical reference: Patrick and Reimer, 1975, p. 33, Pl. 4, Figs. 12a - 13b.

Descriptors: Valve naviculoid. Striae variable, 22 - 26 in 10 µm. Length, 11 - 15. Breadth, 3.6 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Periphytic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Kolkwitz, 1914; Hustedt, 1937 - 1938; Foged, 1948, 1958, 1968a; Patrick and Reimer, 1975). Oligohalobous indifferent (Foged, 1948, 1949, 1954). Beta - mesosaprobic (Fjerdinstadt, 1950). Current indifferent (Foged, 1948, 1954). Appears more commonly in well-aerated habitats (Patrick and Reimer, 1975).

Previous reports from Iowa: Clear Lake (Begres,

Table 56. Summary of distribution and relative abundance for <u>Cymbella</u> <u>mexicana</u> (Ehr.) Cleve var. <u>mexicana</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake					r		r				
West Okoboji							r		r		
Center Lake											
Spirit Lake			r				r		r		
East Okoboji							r				

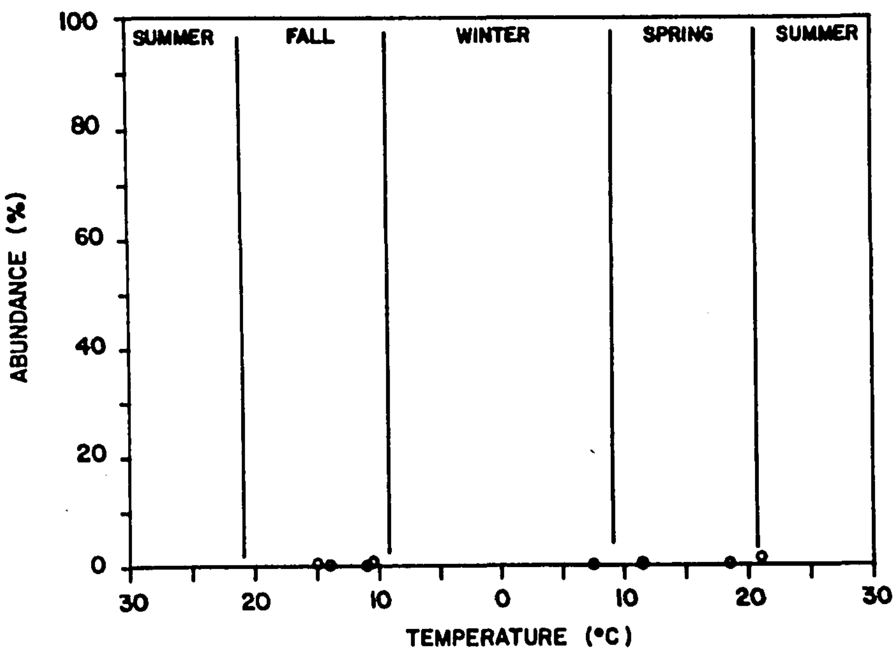

Figure 28. Abundance vs. temperature and season for populations of <u>Cymbella</u> <u>mexicana</u>

1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Silver Lake Fen (Shobe et al., 1963). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

<u>Occurrence</u>: Rare in the plankton of Silver Lake and Spirit Lake (Table 57). Observed during spring and fall. No clear indication of temperature preference.

Table 57. Summary of distribution and relative abundance for <u>Cymbella microcephala</u> v. <u>microcephala</u>

	1979								1980		
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r									
West Okoboji											
Center Lake											
Spirit Lake			r				r	r			
East Okoboji											

<u>Cymbella minuta Hilse ex Rabh. var. minuta</u>

<u>Plate</u>: 20, Fig. 8.

<u>Critical reference</u>: Patrick and Reimer, 1975, p. 47, Pl. 8, Figs. 1a - 4b.

Descriptors: Striae, 14 in 10 µm. Length, 17 µm. Breadth, 5 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977). pH indifferent (Patrick and Reimer, 1975). Oligohalobous (Patrick and Reimer, 1975).

Previous reports from Iowa: Lake West Okoboji (Hosseini, 1979).

Occurrence: Observed in a single spring plankton sample from Lake East Okoboji (Table 58). Rare and no clear indication of periodicity or optimum temperature.

Cymbella minuta var. *silesiaca* (Bleisch *ex* Rabh.) Reim. comb. nov.

Plate: 20, Fig. 10.

Critical reference: Patrick and Reimer, 1975, p. 49, Pl. 8, Figs. 7a - 10b.

Descriptors: Striae, 10 in 10 µm. Length, 19 - 30 µm. Breadth, 7 - 9 µm. Reimer (Patrick and Reimer, 1975) states that this variety is typically larger than the nominate variety.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977). pH indifferent (Patrick and Reimer, 1975). Oligohalobous (Patrick and Reimer, 1975).

Previous reports from Iowa: Skunk River (Beckert, 1977).

Table 58. Summary of distribution and relative abundance for *Cymbella minuta* v. *minuta*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji			r								

Table 59. Summary of distribution and relative abundance for *Cymbella minuta* v. *silesiaca*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake			r						r		
East Okoboji								r			

Occurrence: Rare in the plankton of several lakes (Table 59). Perennial species; no clear indication of periodicity; temperature indifferent.

Cymbella muelleri Hust. var. muelleri

Plate: 21, Figs. 2 and 3.

Critical reference: Patrick and Reimer, 1975, p. 43, Pl. 7, Figs. 1 and 2.

Descriptors: Striae, 10 - 11 in 10 µm (dorsal); 7 - 8 in 10 µm (ventral). Length 40 - 52 µm. Breadth, 17 - 20 µm.

Ecology: Most commonly collected in alkaline springs and lakes (Patrick and Reimer, 1975). Alkaliphilous (Patrick and Reimer, 1975).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1971).

Occurrence: Rare in Lake West Okoboji and Spirit Lake (Table 60). Mesothermal (Figure 29). A spring and summer form.

Cymbella muelleri f. ventricosa (Temp. & Perag.) Reimer comb. nov.

Plate: 21, Fig. 1.

Table 60. Summary of distribution and relative abundance for Cymbella muelleri v. muelleri

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji		r			r						
Center Lake											
Spirit Lake			o								r
East Okoboji											

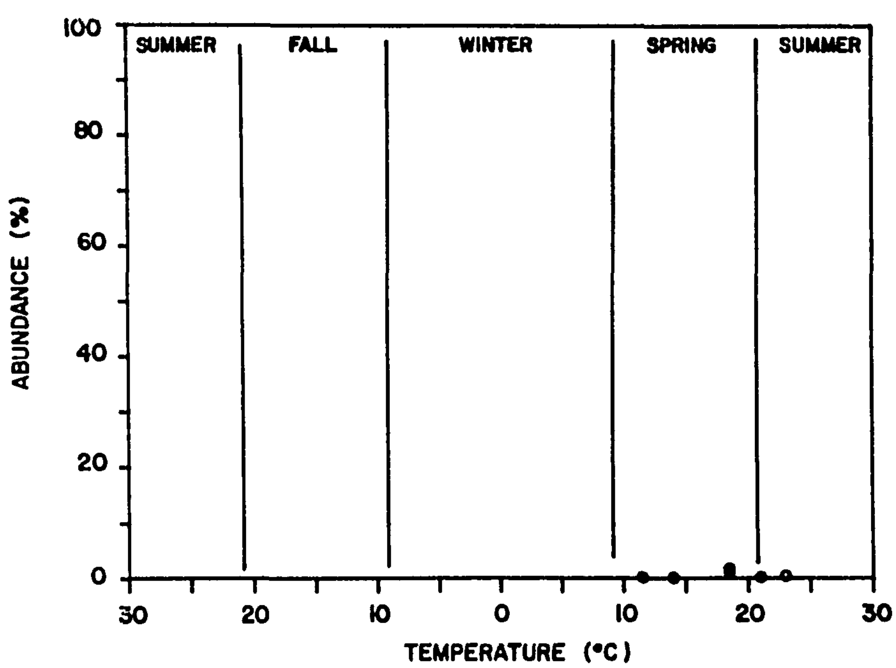

Figure 29. Abundance vs. temperature and season for populations of Cymbella muelleri

Critical reference: Patrick and Reimer, 1975, p. 44, Pl. 7, Figs. 3a - 4.

Descriptors: Striae, 9 in 10 µm (dorsal), 8 in 10 µm (ventral). Length, 40.5 µm. Breadth, 17.6 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: None.

Occurrence: Less common than the nominate variety (Table 61). Observed in a spring sample in Spirit Lake. The periodicity and temperature preference are not apparent.

Cymbella prostrata (Berk.) Cleve var. *prostrata*

Plate: 20, Fig. 6.

Critical reference: Patrick and Reimer, 1975, p. 40, Pl. 6, Fig. 4.

Descriptors: Striae, 6 - 10 in 10 µm. Length, 30 - 58 µm. Breadth, 11 - 20 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Jorgensen, 1948); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1954, 1968a; Hustedt, 1957; Cholnoky, 1968; Patrick and Reimer, 1975). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1954; Hustedt, 1957). Oligosaprobic (Kolkwitz and Marsson, 1908; Blum, 1957; Hustedt, 1957). Rheophilous (Foged, 1948, 1954). Seasonal maximum - summer

Table 61. Summary of distribution and relative abundance for *Cymbella muelleri* f. *ventricosa*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											r
East Okoboji											

(Blum, 1957).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hostetter and Stoermer, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Coralville Reservoir (Schmidt and Fee, 1967). Des Moines River (Drum, 1964). Skunk River (Beckert, 1977).

Occurrence: Rare in the winter plankton of Spirit Lake and the spring plankton of Lake West Ojoboji (Table 62). No clear indication of periodicity or optimum temperature.

Cymbella proxima Reimer var. *proxima*

Plate: 21, Fig. 4.

Critical reference: Patrick and Reimer, 1975, p. 61, Pl. 11, Fig. 1.

Descriptors: Striae, 7 - 9 in 10 µm. Length, 49 - 114. Breadth, 17 - 25 µm.

Ecology: Not observed in streams or rivers, appears to be more characteristic of lakes (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: A fall and winter species encountered only in the plankton of Lake West Okoboji and Center Lake (Table 63). Temperature indifferent.

Table 62. Summary of distribution and relative abundance for *Cymbella prostrata* v. *prostrata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake								r			
West Okoboji		r									
Center Lake											
Spirit Lake											
East Okoboji											

Table 63. Summary of distribution and relative abundance for *Cymbella proxima* v. *proxima*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji					r	r	r		r		
Center Lake			r								
Spirit Lake											
East Okoboji											

<u>Cymbella sinuata</u> Greg. var. <u>sinuata</u>

<u>Plate</u>: 21, Fig. 7.

<u>Critical reference</u>: Patrick and Reimer, 1975, p. 51, Pl. 9, Figs. 3a - 4b.

<u>Descriptors</u>: Striae, 11 in 10 µm. Length, 16.2 µm. Breadth, 4.5 µm.

<u>Ecology</u>: Freshwater rivers (Hohn and Hellerman, 1963; Collins and Kalinksy, 1977); lakes (Stoermer and Yang, 1969). Periphytic (Hustedt, 1937 - 1938); euplanktonic (Stoermer and Yang, 1969). pH indifferent (Foged, 1948, 1954, 1968b; Cholnoky, 1968; Patrick and Reimer, 1975). Oligohalobous indifferent (Foged, 1948, 1954, 1964). Limnobiontic (Foged, 1948, 1954). Eurythermal (Scheele, 1952) to mesothermal (Scheele, 1952).

<u>Previous reports from Iowa</u>: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969). Dutch Creek (Fee, 1967). Skunk River (Beckert, 1977).

<u>Occurrence</u>: Rare in the plankton of the Iowa Lakes Region (Table 64). No indication of periodicity. Temperature indifferent.

<u>Cymbella triangulum</u> (Ehr.) Cleve var. <u>triangulum</u>

<u>Plate</u>: 21, Fig. 5 and 6.

Table 64. Summary of distribution and relative abundance for *Cymbella sinuata* v. *sinuata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake								r			
East Okoboji				r							

Table 65. Summary of distribution and relative abundance for *Cymbella triangulum* v. *triangulum*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r			r	r			
West Okoboji											
Center Lake											
Spirit Lake										r	
East Okoboji					r						

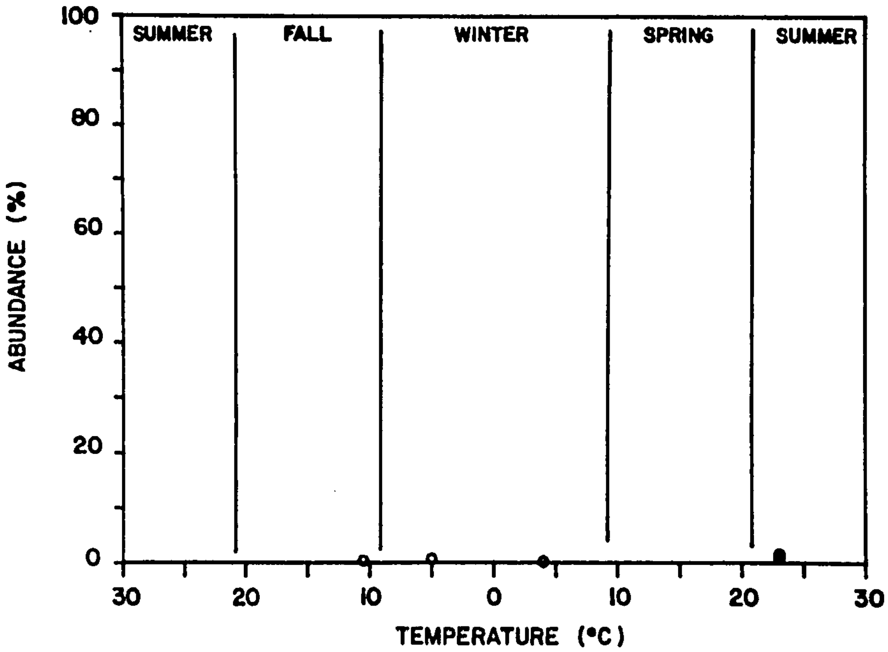

Figure 30. Abundance vs. temperature and season for populations of Cymbella triangulum

Critical reference: Patrick and Reimer, 1975, p. 45, Pl. 7, Figs. 7 - 10.

Descriptors: Striae, 8 - 11 in 10 µm. Length, 30 - 65 µm. Breadth, 13 - 20 µm.

Ecology: Moderately hard - water streams, pH indifferent (Patrick and Reimer, 1975). Fresh water, lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Coralville Reservoir (Schmidt and Fee, 1967). Farm ponds (Ohl, 1965). Soil (Loescher, 1971). Epizoic (Fee and Drum, 1965).

Occurrence: Observed in three lakes, always rare (Table 65). Temperature indifferent (Figure 30). Possibly a perennial taxon.

Cymbellonitzschia diluviana Hust. var. *diluviana*

Plate: 23, Fig. 9.

Critical reference: Hustedt, 1954, p. 453, Fig. 23.

Descriptors: Striae, 23 in 10 µm. Keel punctae, 10 in 10 µm. Length, 18.5 µm. Breadth, 4 µm.

Ecology: Insufficiently known.

Table 66. Summary of distribution and relative abundance for *Cymbellonitzschia diluviana* v. *diluviana*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				o							

Table 67. Summary of distribution and relative abundance for *Diatoma vulgare* v. *vulgare*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r				r		r	
Center Lake											
Spirit Lake			r					r			r
East Okoboji			r				r	c			

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a).

Occurrence: Observed only in plankton samples from Lake East Okoboji (Table 66). No clear indication of periodicity or temperature preference.

Diatoma vulgare Bory var. *vulgare*

Plate: 9, Fig. 3.

Critical reference: Patrick and Reimer, 1966, p. 109. Pl. 2, Fig. 9.

Descriptors: Striae, 16 in 10 µm. Length, 46 - 51 µm. Breadth, 10 - 14 µm. Costae, 6 - 8 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Jorgensen, 1948); euplanktonic (Stoermer and Yang, 1969); epiphytic (Jorgensen, 1948). Alkalibiontic to alkaliphilous (Foged, 1948, 1949, 1954; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1948, 1949, 1954; Hustedt, 1957). Beta - mesosaprobic to oligosaprobic (Kolkwitz and Marsson, 1908; Fjerdingstadt, 1950; Hustedt, 1957). Rheophilous (Foged, 1948, 1954; Hustedt, 1930a, 1957). Eurythermal to mesothermal (Scheele, 1952). Seasonal maximum - winter (Blum, 1957).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Beckert, 1977). Brewer's Creek (Edwards and Christensen, 1973). Dutch Creek (Fee, 1967).

<u>Occurrence</u>: Rare in the plankton of several lakes (Table 67). Perennial entity. Greatest abundance observed during winter (Figure 31).

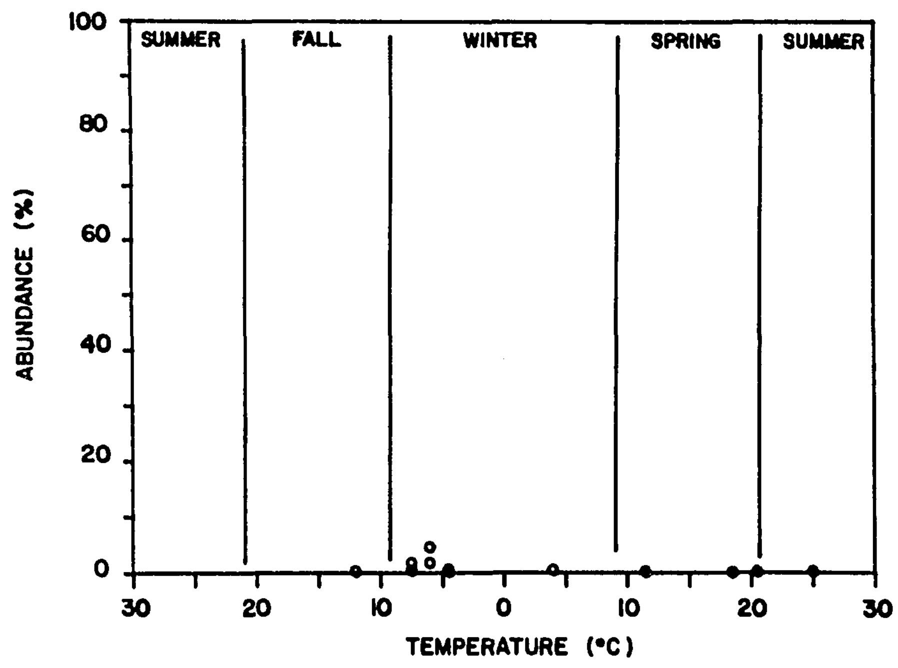

Figure 31. Abundance vs. temperature and season for populations of *Diatoma vulgare*

Diploneis oculata (Breb.) Cleve var. oculata

Plate: 13, Fig. 4.

Critical reference: Patrick and Reimer, 1966, p. 412, Pl. 38, Fig. 6.

Descriptors: Striae radiate, > 28 in 10 µm. Length, 18 µm. Breadth, 7.2 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Fresh water of variable mineral content (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968).

Occurrence: Observed in a single spring plankton sample from Spirit Lake (Table 68). No clear indication of periodicity or optimum temperature.

Entomoneis ornata (J.W. Bail.) Reim. comb. nov., var. ornata

Plate: 17, Fig. 5.

Critical reference: Patrick and Reimer, 1975, p. 4, Pl. 1, Figs. 3 - 4.

Descriptors: Striae, 21 in 10 µm. Length, 72.4 µm. Breadth 19 µm.

Ecology: Freshwater lakes (Hustedt, 1930a; Stoermer and Yang, 1969); streams and rivers (Hustedt, 1930a; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Hustedt, 1930a). pH indifferent (Hustedt, 1937 -

Table 68. Summary of distribution and relative abundance for *Diploneis oculata* v. *oculata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake		r									
East Okoboji											

Table 69. Summary of distribution and relative abundance for *Entomoneis ornata* v. *ornata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r	r	r	r	r	r		
West Okoboji											
Center Lake		r	r		r						r
Spirit Lake											
East Okoboji	r										

1938) to acidophilous (Hustedt, 1937 - 1938). Oligohalobous halophobous (Hustedt, 1957). Saproxenous (Hustedt, 1937 - 1938).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Spirit Lake (Krohn et al., 1974). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976).

Occurrence: Observed frequently in plankton samples from Silver Lake and Center Lake, but always rare (Table 69). A perennial species. Temperature indifferent (Figure 32).

Epithemia adnata var. *porcelus* (Kutz.) Patrick

Plate: 24, Fig. 5.

Critical reference: Patrick and Reimer, 1975, p. 180, Pl. 24, Fig. 6.

Descriptors: Length, 58 µm. Breadth, 13 µm. Striae, 8 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Prefers water of fairly high conductivity (Patrick and Reimer, 1975).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Drainage ditches (Lowe, 1970; Edwards, 1974). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Farm ponds (Ohl, 1965).

Occurrence: Rare, in a single plankton sample from

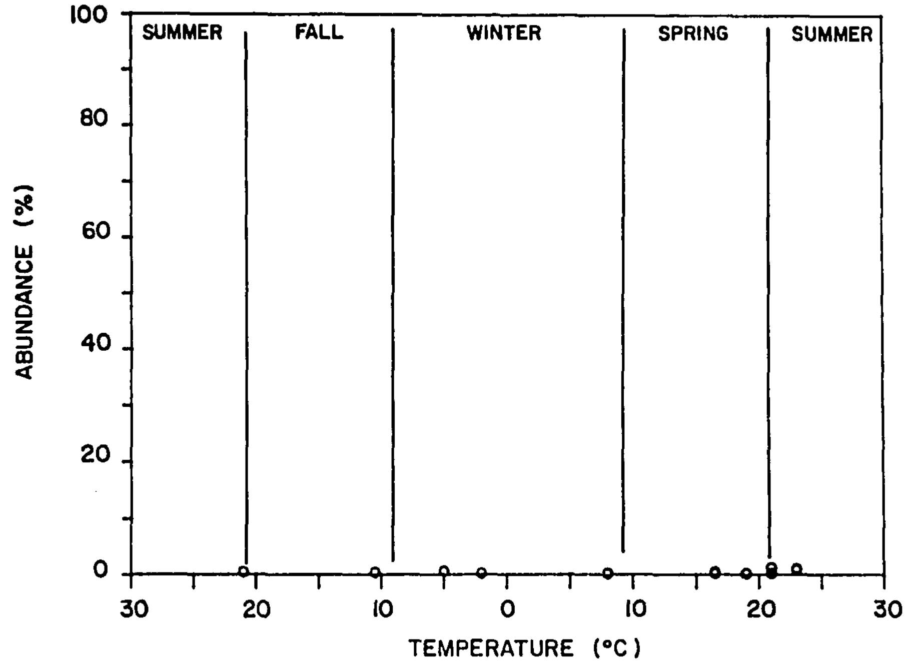

Figure 32. Abundance vs. temperature and season for populations of Entomoneis ornata

Table 70. Summary of distribution and relative abundance for Epithemia adnata v. porcellus

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake					r						
Spirit Lake											
East Okoboji											

Table 71. Summary of distribution and relative abundance for Epithemia intermedia v. intermedia

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Center Lake (Table 70).

Epithemia intermedia Fricke var. intermedia

Plate: 25, Fig. 4.

Critical reference: Patrick and Reimer, 1975, p. 179, Pl. 24, Fig. 2.

Descriptors: Alveoli rows, 11 in 10 µm. Costae, 4 in 10 µm. Length, 37 µm. Breadth, 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Freshwater of moderately high conductivity (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: Encountered in a single summer sample from Lake West Okoboji (Table 71). Rare, and no clear indication of periodicity or optimum temperature.

Epithemia ocellata (Ehr.) Kutz. var. ocellata

Plate: 24, Fig. 7.

Critical reference: Patrick and Reimer, 1975, p. 178, Pl. 24, Fig. 1.

Descriptors: Alveoli rows, 12 in 10 µm. Costae, 3 in 10 µm. Length, 38 µm. Breadth, 8.4 µm.

Ecology: Freshwater with moderately high conductivity (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: Observed in a single, fall plankton sample from Lake West Okoboji (Table 72). No clear indication of periodicity or temperature preference.

Epithemia turgida (Ehr.) Kutz. var. turgida

Plate: 26, Fig. 6.

Critical reference: Patrick and Reimer, 1975, p. 182, Pl. 25, Figs. 1a - b.

Descriptors: Alveoli rows, 8 in 10 µm. Costae, 4 in 10 µm. Length, 115 µm. Breadth, 16 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Littoral species (Patrick and Reimer, 1975). Alkaliphilous (Patrick and Reimer, 1957).

Previous reports from Iowa: Clear Lake (Begres, 1971). Spirit Lake (Krohn et al., 1974). Lake West Okoboji (Hosseini, 1979). Des Moines River (Gudmundson, 1969). Skunk River (Beckert, 1977). Farm ponds (Ohl, 1965). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton from Spirit Lake (Table 73). No clear indication of periodicity or optimum temperature.

Table 72. Summary of distribution and relative abundance for *Epithemia ocellata* v. *ocellata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji						r					
Center Lake											
Spirit Lake											
East Okoboji											

Table 73. Summary of distribution and relative abundance for *Epithemia turgida* v. *turgida*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake							r				
East Okoboji											

Epithemia turgida var. westermanii (Ehr.) Grun.

Plate: 24, Fig. 4; and Pl. 25, Fig. 1.

Critical reference: Patrick and Reimer, 1975, p. 184, Pl. 25, Figs. 2a - b.

Descriptors: Alveoli rows, 9 - 10 in 10 µm. Costae, 5 - 6 in 10 µm. Length, 48 - 68 µm. Breadth, 13 - 14 µm.

Ecology: Freshwater (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: Rare in the summer plankton of Silver Lake and Lake West Okoboji (Table 74). No clear indication of periodicity or optimum temperature.

Eunotia curvata (Kutz.) Lagerst. var. curvata

Plate: 11, Fig. 11.

Critical reference: Patrick and Reimer, 1966, p. 189, Pl. 10, Fig. 4.

Descriptors: Length, 38 µm. Breadth, 3.6 µm. Striae, 16 in 10 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); ponds (Jorgensen, 1948; Patrick and Reimer, 1966); rivers (Patrick and Reimer, 1966; Collins and Kalinsky, 1977). Tychoplanktonic or periphytic (Schroeder, 1939). Acidophilous (Hustedt, 1937 - 1938; Foged, 1948; Patrick and Reimer, 1966; Cholnoky, 1968); pH indifferent (Foged, 1949, 1953; Hustedt, 1957). Eutrophic to oligotrophic (Jorgensen, 1948). Halobion indifferent (Foged, 1949, 1953, Hustedt,

Table 74. Summary of distribution and relative abundance for *Epithemia turgida* v. *westermanii*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r								
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Table 75. Summary of distribution and relative abundance for *Eunotia curvata* v. *curvata*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		r									
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

1957); halophobous (Petersen, 1943; Foged, 1948). Oligosaprobic (Hustedt, 1957). Current indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Brewer's Creek (Edwards and Christensen, 1973). Pilot Knob Bog (Christensen, 1976). Drainage ditches (Lowe, 1970; Edwards, 1974). Clear Lake and Ventura marsh (Begres, 1971). Lake East Okoboji (Volker, 1963). Lake West Okoboji (Collins, 1968). Farm ponds (Ohl, 1965). Cayler Prairie (Reimer, 1970). Excelsior Fen (Shobe et al. 1963).

Occurrence: Rare in a single plankton sample from Silver Lake (Table 75).

Eunotia glacialis Meist. var. glacialis

Plate: 11, Fig. 10.

Critical reference: Patrick and Reimer, 1966, p. 188, Pl. 10, Fig. 3.

Descriptors: Length, 100 μm. Breadth, 5.4 μm. Striae, 11 in 10 μm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977).

Previous reports from Iowa: None.

Occurrence: Rare in a single plankton sample from Lake West Okoboji (Table 76).

Fragilaria brevistriata Grun. var. brevistriata

Plate: 9, Fig. 8.

Table 76. Summary of distribution and relative abundance for <u>Eunotia</u> <u>glacialis</u> var. <u>glacialis</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji										r	
Center Lake											
Spirit Lake											
East Okoboji											

Critical reference: Patrick and Reimer, 1966, p. 128, Pl. 4, Fig. 14.

Descriptors: Striae, 14 in 10 µm. Length, 16 - 24 µm. Breadth, 3.6 - 4 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977); lakes (Jorgensen, 1948; Stoermer and Yang, 1969) Periphytic (Hustedt, 1930a, 1937 - 1938); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1954, 1968a; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Hustedt, 1937 - 1938; Foged, 1948, 1954; 1968a). Eutrophic (Jorgensen, 1948). Oligosaprobic (Hustedt, 1957). Stoermer and Yang (1969) report that the published records indicate that this taxon reaches its greatest abundance in smaller mesotrophic to eutrophic lakes. Current indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Drainage ditches (Edwards, 1974). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: A perennial species, rare in the plankton of all the lakes (Table 77). Temperature indifferent (Figure 33).

Fragilaria brevistriata var. capitata Herib.

Plate: 9, Fig. 7.

Table 77. Summary of distribution and relative abundance for Fragilaria brevistriata v. breuistriata

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		o	o	o	r	r	r	r			
West Okoboji				r	r		r				
Center Lake				r							
Spirit Lake							r				
East Okoboji			r	r							

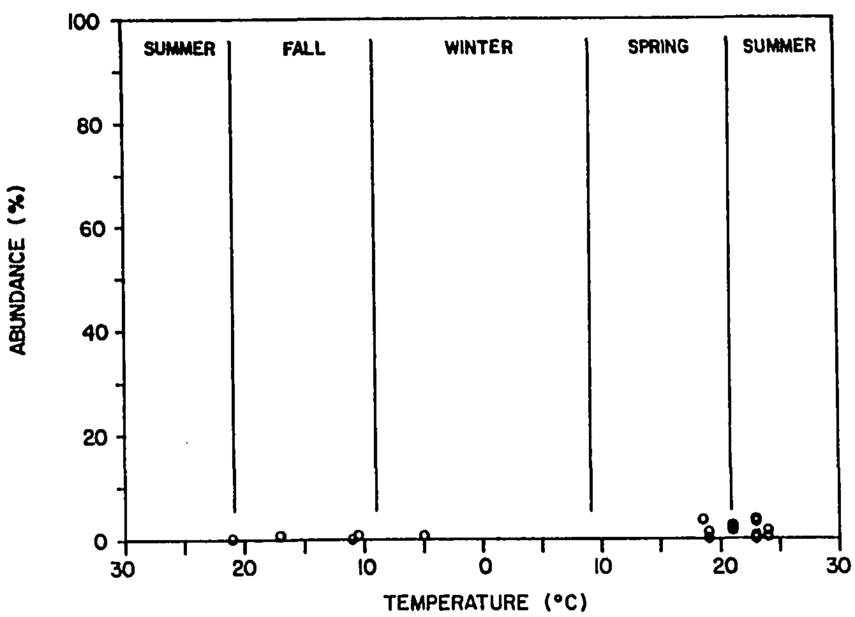

Figure 33. Abundance vs. temperature and season for populations of Fragilaria brevistriata

Critical reference: Patrick and Reimer, 1966, p. 129, Pl. 4, Fig. 15.

Descriptors: Striae, 14 in 10 µm. Length, 18 µm. Breadth, 4.5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Drainage ditches (Edwards, 1974). Skunk River (Beckert, 1977).

Occurrence: Observed in a single, summer plankton sample from Lake West Okoboji (Table 78). Less common than the nominate variety. No clear indication of periodicity and optimum temperature.

Fragilaria brevistriata var. *inflata* (Pant.) Hust.

Plate: 9, Fig. 6.

Critical reference: Patrick and Reimer, 1966, p. 129, Pl. 4, Fig. 16.

Descriptors: Striae, 12 - 16 in 10 µm. Breadth, 3.6 - 5.4 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1958; Jorgensen, 1948; Patrick and Reimer, 1966).

Occurrence: More common than the nominate variety, but always rare (Table 79). Perennial species, observed

Table 78. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>brevistriata</u> v. <u>capitata</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake											
East Okoboji											

Table 79. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>brevistriata</u> v. <u>inflata</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r	r	r	r	r	r	r	r		
West Okoboji				r	r	r	r		r		r
Center Lake				r	r	r					
Spirit Lake								r	r		
East Okoboji	r								r		

during all seasons (Figure 34). Frequency of occurrence greater in Silver Lake and Lake West Okoboji. Temperature indifferent.

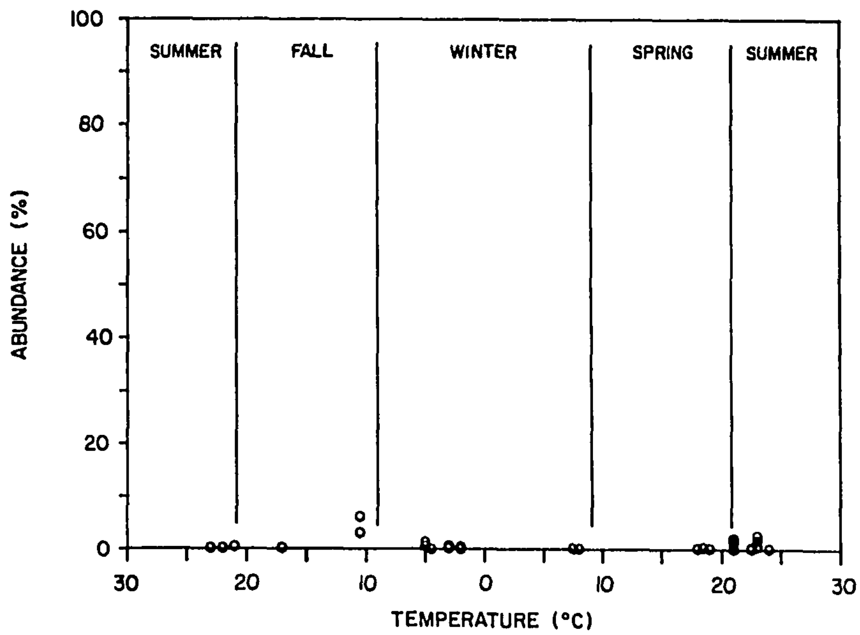

Figure 34. Abundance vs. temperature and season for populations of <u>Fragilaria brevistriata</u> v. <u>inflata</u>

Fragilaria capucina Desm. var. capucina

Plate: 9, Fig. 9.

Critical reference: Patrick and Reimer, 1966, p. 118, Pl. 3, Fig. 5.

Descriptors: Striae, 13 - 15 in 10 µm. Length, 36 - 45 µm. Breadth 3 - 4 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977); periphytic (Hustedt, 1930a, 1937 - 1938); tychoplanktonic (Hustedt, 1930a, 1937 - 1938); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1949, 1954, 1964; Jorgensen, 1948; Hustedt, 1957; Cholnoky, 1968; Patrick and Reimer, 1966). Eutrophic (Hustedt, 1930a, 1937 - 1938; Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1949, 1953, 1954; Hustedt, 1957; Patrick and Reimer, 1966). Oligosaprobic (Fjerdingstadt, 1950; Kolkwitz, 1914; Hustedt, 1957). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Eurythermal (Scheele, 1952), oligothermal (Scheele, 1952) to mesothermal (Scheele, 1952). Seasonal maximum - spring (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). North Twin Lake (Kutkukn, 1958). Des Moines River (Drum, 1964). Farm ponds (Ohl, 1965). Spirit Lake (Krohn et al., 1974).

Table 80. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>capucina</u> v. <u>capucina</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake					r			r	c	c	a
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

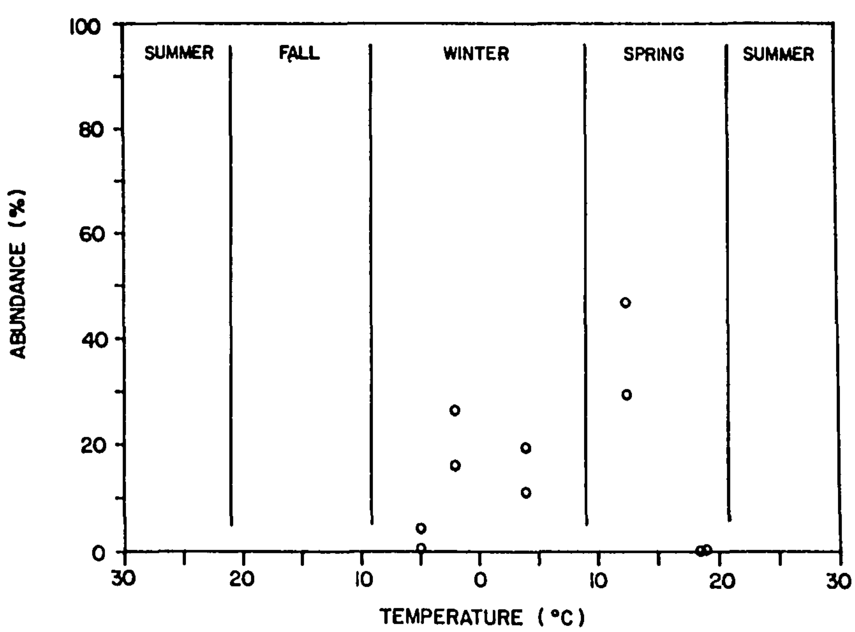

Figure 35. Abundance vs. temperature and season for populations of <u>Fragilaria</u> <u>capucina</u>

Occurrence: Appears to be a winter - spring form (Table 80) (Figure 35). Quite common in the plankton of Silver Lake, rare in Spirit Lake. Oligothermal.

Fragilaria capucina var. *mesolepta* Rabh.

Plate: 9, Fig. 10.

Critical reference: Patrick and Reimer, 1966, p. 119, Pl. 3, Fig. 6.

Descriptors: Striae, 15 - 16 in 10 µm. Length, 12 - 106 µm. Breadth, 3 - 5 µm.

Ecology: Freshwater rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964; Gudmundson, 1969). Spirit Lake (Krohn et al., 1974). Drainage ditches (Edwards, 1974). Farm ponds (Ohl, 1965). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: A perennial species which is quite common in the plankton of all the lakes (Table 81) (Figure 36). Oligothermal, declines at temperatures above 10°C. Much more common than the nominate variety.

Table 81. Summary of distribution and relative abundance for Fragilaria capucina v. mesolepta

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake	r	o	a	a	a		c	c	a	a	a
West Okoboji		a	o	c	o	r	o	a	c	c	c
Center Lake				r	r	r		o			c
Spirit Lake	o	a	a	c	r		r	c	r	r	c
East Okoboji	c	o	c	r	r	r	o	a	c	a	o

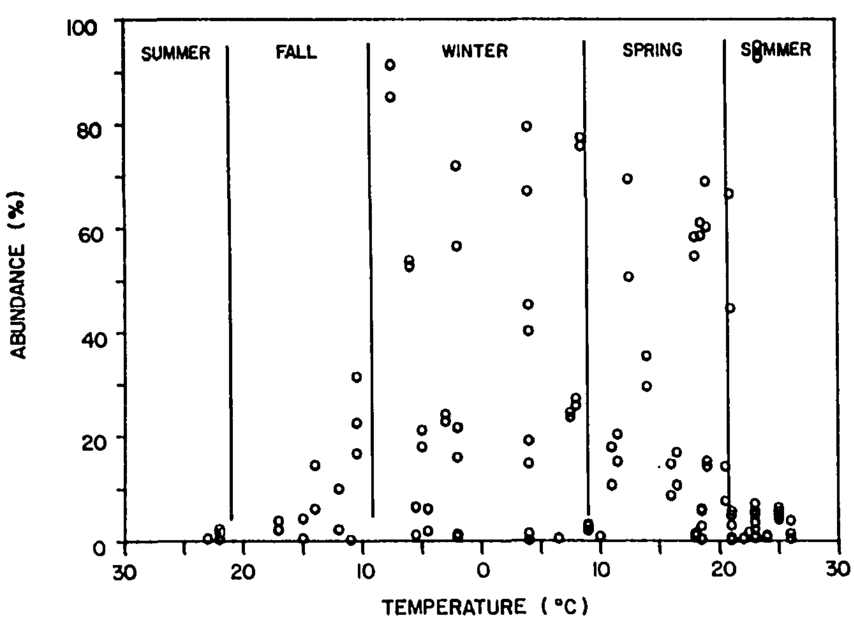

Figure 36. Abundance vs. temperature and season for populations of Fragilaria capucina v. mesolepta

Fragilaria construens (Ehr.) Grun. var. construens

Plate: 9, Fig. 12.

Critical reference: Patrick and Reimer, 1966, p. 125, Pl. 4, Fig. 4.

Descriptors: Striae, 13 - 17 in 10 µm. Length, 9 - 20 µm. Breadth, 6 - 8 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Jorgensen, 1948; Manguin, 1952); euplanktonic (Stoermer and Yang, 1969); tychoplanktonic (Patrick and Reimer, 1966). Alkaliphilous (Foged, 1948, 1954, 1964; Jorgensen, 1948; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1948, 1953, 1954; Hustedt, 1957; Patrick and Reimer, 1966). Oligosaprobic to alpha - mesosaprobic (Kolkwitz and Marsson, 1908; Fjerdingstadt, 1950; Hustedt, 1957). Current indifferent (Foged, 1948, 1954). Eurythermal (Scheele, 1952) and oligothermal to mesothermal (Scheele, 1952). Seasonal maximum - fall (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Drainage ditches (Edwards, 1974). Des Moines River (Drum, 1964). Skunk River (Roeder, 1976; Beckert, 1977). Soil (Loescher, 1971). Arend's Kettle Hole (Collins, 1968).

Table 82. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>construens</u> v. <u>construens</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		o	r	o	r	r	r	r			
West Okoboji				r	r		r			r	r
Center Lake				r	r						
Spirit Lake								r	r	r	
East Okoboji		r							r		

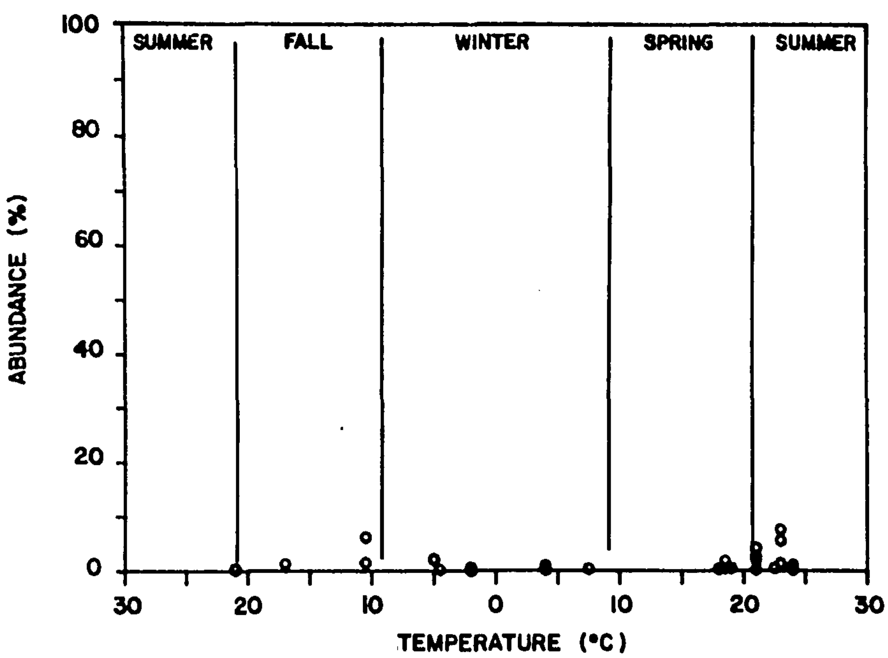

Figure 37. Abundance vs. temperature and season for populations of <u>Fragilaria</u> <u>construens</u>

Occurrence: Observed in plankton samples from all of the lakes, more frequently encountered in Silver Lake (Table 82). A perennial species; temperature indifferent (Figure 37).

Fragilaria construens var. binodis (Ehr.) Grun.

Plate: 9, Fig. 13.

Critical reference: Patrick and Reimer, 1966, p. 125, Pl. 4, Fig. 7.

Descriptors: Striae, 13 - 14 in 10 µm. Length, 22 - 25 µm. Breadth, 5 - 6 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: As common as the nominate variety, though its occurrence was not as broad (Table 83). Always rare; perennial, with no clear indication of temperature preference (Figure 38).

Fragilaria construens var. venter (Ehr.) Grun.

Plate: 9, Fig. 14.

Critical reference: Patrick and Reimer, 1966, p. 126, Pl. 4, Figs. 8 - 9.

Descriptors: Striae, 15 - 16 in 10 µm. Length, 4 -

Table 83. Summary of distribution and relative abundance for *Fragilaria construens* v. *binodis*

Lake	Apr 1979	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan 1980	Mar	Apr
Silver Lake		r									
West Okoboji		r	r	r	r		r		r	r	o
Center Lake					r						
Spirit Lake											
East Okoboji		r	r	o	r	r	o	r		r	

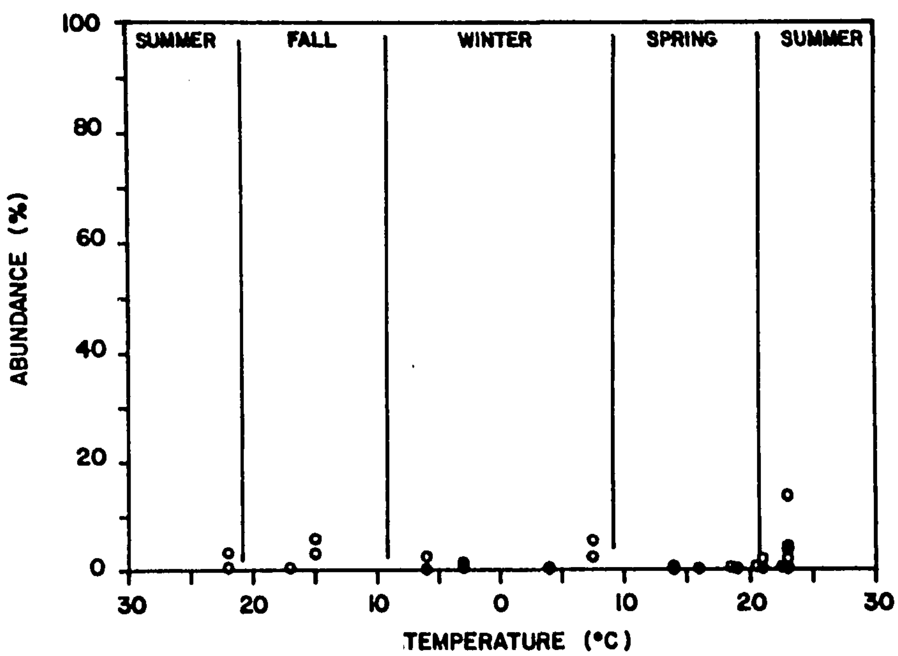

Figure 38. Abundance vs. temperature and season for populations of *Fragilaria construens* v. *binodis*

6 µm. Breadth, 3 - 6 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hustedt, 1937 - 1938; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Manguin, 1952); tychoplanktonic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1953, 1968a; Jorgensen, 1948; Hustedt, 1957). Oligotrophic to mesotrophic (Patrick and Reimer, 1966). Oligohalobous indifferent (Foged, 1948, 1949, 1954, 1968a; Hustedt, 1957; Patrick and Reimer, 1966). Mesosaprobic to saprophobic (Jorgensen, 1948). Limnobiontic (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Drainage ditches (Edwards, 1974). Farm ponds (Ohl, 1965). Soil (Loescher, 1971). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Less common than the nominate variety (Table 84). Observed only in samples from Lake West Okoboji and Spirit Lake. No clear indication of periodicity or temperature preference.

Fragilaria crotonensis Kitton var. *crotonensis*

Plate: 9, Fig. 11. Plate 10, Fig. 2.

Critical reference: Patrick and Reimer, 1966, p. 121, Pl. 3, Figs. 11 - 12.

Descriptors: Striae, 13 - 14 in 10 µm. Length, 72 - 123 µm. Breadth, 2 - 3 µm.

Table 84. Summary of distribution and relative abundance for *Fragilaria construens* v. *venter*

	1979								1980		
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji		r		r							
Center Lake											
Spirit Lake									r		
East Okoboji											

Table 85. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>crotonensis</u> v. <u>crotonensis</u>

	1979								1980		
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		a	c								
West Okoboji		a	a	a	c	c	o	o			
Center Lake	a	a	a	c	c	r	r	c	r		a
Spirit Lake		o		c	r						
East Okoboji		r	r	c		r			r		

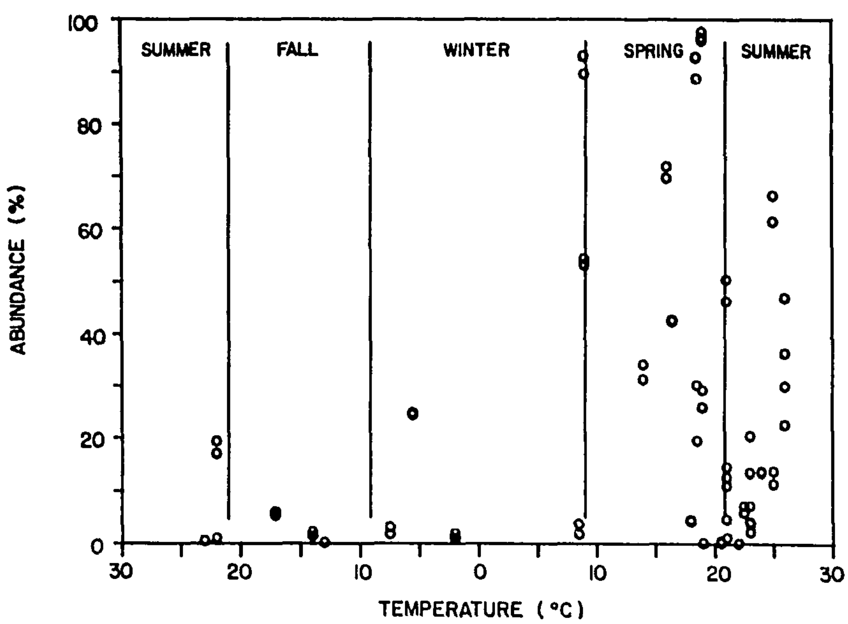

Figure 39. Abundance vs. temperature and season for populations of <u>Fragilaria</u> <u>crotonensis</u>

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Foged, 1954; Patrick and Reimer, 1966; Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1949, 1953, 1964; Hustedt, 1930a, 1957; Jorgensen, 1952; Cholnoky, 1968). Eutrophic (Hustedt, 1930a) to mesotrophic (Patrick and Reimer, 1966). Oligohalobous indifferent (Foged, 1948, 1953, 1964; Kolbe, 1927; Patrick and Reimer, 1966). Oligosaprobic (Kolkwitz, 1914; Hustedt, 1957). Current indifferent (Hustedt, 1930a; Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969). Farm ponds (Ohl, 1965). Cayler Prairie (Reimer, 1970). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Quite common throughout the Lake District (Table 85). Greatest abundance observed at temperatures above 10°C, during the spring and summer (Figure 39). Generally less abundant during fall and winter.

Fragilaria crotonensis var. *oregona* Sov.

Plate: 10, Fig. 1.

Critical reference: Patrick and Reimer, 1966, p. 122, Pl. 3, Fig. 13.

Descriptors: Striae, 13 in 10 µm. Length, 131 µm. Breadth, 3 µm. Not clearly separable from the nominate variety. Possibly an aberrant population which should be placed in synonymy.

Ecology Freshwater pH 8.1 - 8.8, alkalibiontic (Patrick and Reimer, 1966). Lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968).

Occurrence: Quite rare (Table 86). Observed only in samples from Lake West Okoboji. No clear indication of periodicity or optimum temperature.

Fragilaria lapponica Grun. lapponica

Plate: 9, Figs. 15 and 16.

Critical reference: Patrick and Reimer, 1966, p. 130, Pl. 4, Fig. 17.

Descriptors: Striae, 8 in 10 µm. Length, 19 µm. Breadth, 4 - 5 µm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977). Seems to prefer circumneutral water of low mineral content, indifferent to small amounts of NaCl (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Des Moines River (Drum, 1964). Arend's Kettle Hole (Collins, 1968). Pillsbury and

Table 86. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>crotonensis</u> v. <u>oregona</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake				r							
East Okoboji											

Sylvan Lake beds (Hungerford, 1972).

Occurrence: A rare form in the plankton of the Lake District (Table 87). No clear indication of periodicity or temperature preference.

Table 87. Summary of distribution and relative abundance for *Fragilaria lapponica* v. *lapponica*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r						r			
West Okoboji			r								
Center Lake											
Spirit Lake				r							
East Okoboji											

Fragilaria pinnata Ehr. var. *pinnata*

Critical reference: Patrick and Reimer, 1966, p. 127, Pl. 4, Fig. 10.

Descriptors: Striae, 13 - 14 in 10 µm. Length, 9 - 10 µm. Breadth, 4 - 5 µm.

Ecology: Freshwater rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Jorgensen, 1948; Stoermer and Yang, 1969). Periphytic (Hustedt, 1930a, 1937 - 1938); tychoplanktonic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1953, 1958; Cholnoky, 1968). Oligohalobous indifferent (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1953, 1954; Manguin, (1952). Oligosaprobic (Hustedt, 1957) to beta - mesosaprobic (Fjerdingstadt, 1950). Current indifferent (Foged, 1948, 1954) to limnobiontic (Hornung, 1959).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Des Moines River (Drum, 1964). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: A perennial species, rare in the plankton of all the lakes (Table 88). Observed during all seasons. Temperature indifferent (Figure 40).

Fragilaria pinnata var. *intercedens* (Grun.) Hust.

Critical reference: Patrick and Reimer, 1966, p. 127,

Table 88. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>pinnata</u> v. <u>pinnata</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		o		r	r	r		r			
West Okoboji				o	o	o	r	r	r	r	o
Center Lake					r						
Spirit Lake			r					r	r		
East Okoboji			r	r		r	r				

Table 89. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>pinnata</u> v. <u>interedens</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r							
West Okoboji											
Center Lake											
Spirit Lake				r							
East Okoboji											

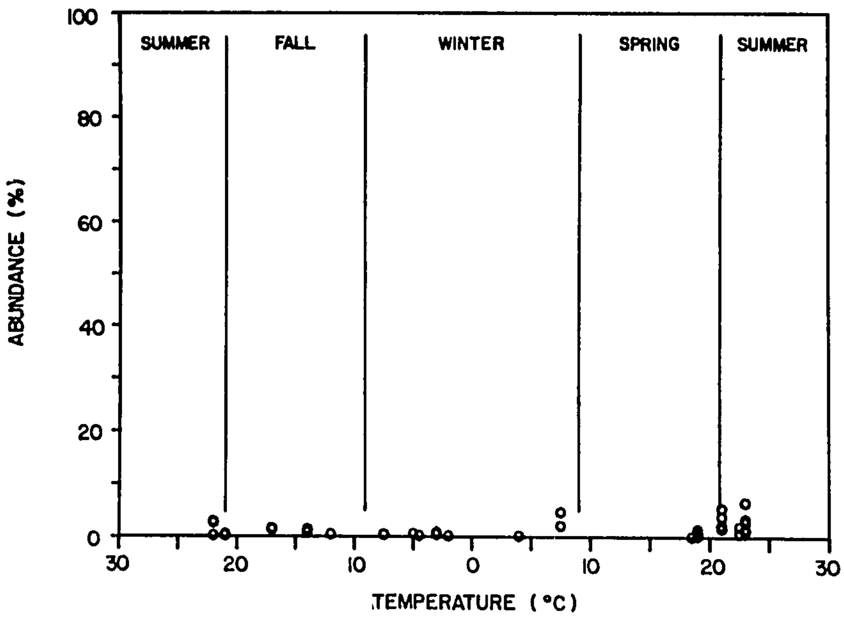

Figure 40. Abundance vs. temperature and season for populations of *Fragilaria pinnata*

Pl. 4, Fig. 11.

Descriptors: Striae, 8 in 10 µm. Length, 16 - 17 µm. Breadth, 5 - 6 µm.

Ecology: Freshwater streams (Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). A tolerant fresh-water taxon (Patrick and Reimer, 1966).

Previous reports from Iowa: None.

Occurrence: Rarer than the nominate variety (Table 89). Observed in samples from Silver Lake and Spirit Lake. No clear indication of periodicity or optimum temperature.

Fragilaria pinnata var. *lancettula* (Schum.) Hust.

Plate: 10, Fig. 4.

Critical reference: Patrick and Reimer, 1966, p. 128, Pl. 4, Fig. 12.

Descriptors: Striae, 10 - 11 in 10 µm. Length, 13 - 14 µm. Breadth 3 - 5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Fresh water to slightly brackish or water of high conductivity (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968).

Occurrence: Less commonly encountered than the nominate variety (Table 90). Seems to be a perennial species

Table 90. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>pinnata</u> var. <u>lancettula</u>

			1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r							
West Okoboji	r						r			r	
Center Lake											
Spirit Lake							r				
East Okoboji											

Table 91. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>vaucheriae</u> v. <u>vaucheriae</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r	c	r	r		r		r		
West Okoboji		r	r	c	o	o	o		c	c	a
Center Lake		r	r	r	r						r
Spirit Lake		r	c	r	r		r	c			c
East Okoboji	o	r	r	r	r	o	r	c	o	r	o

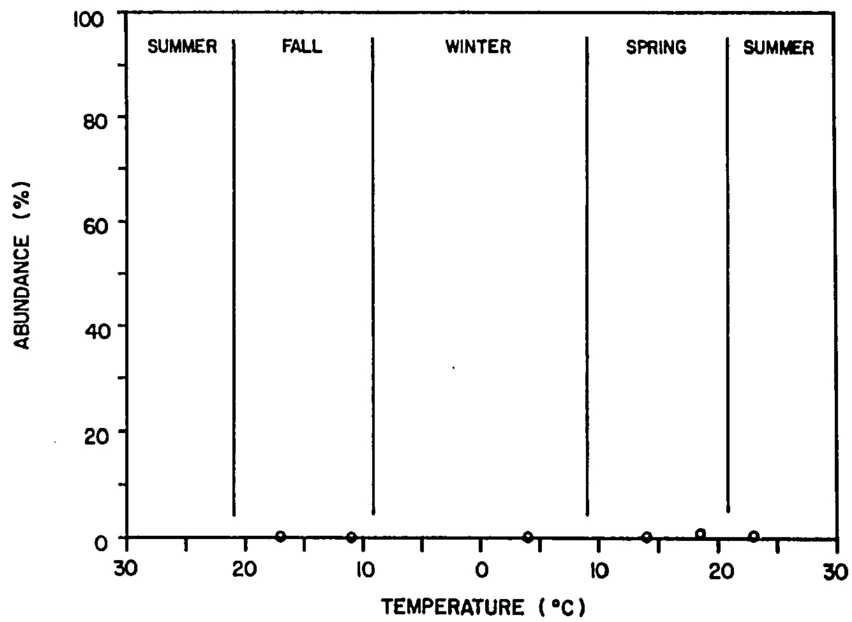

Figure 41. Abundance vs. temperature and season for populations of <u>Fragilaria pinnata</u> v. <u>lancettula</u>

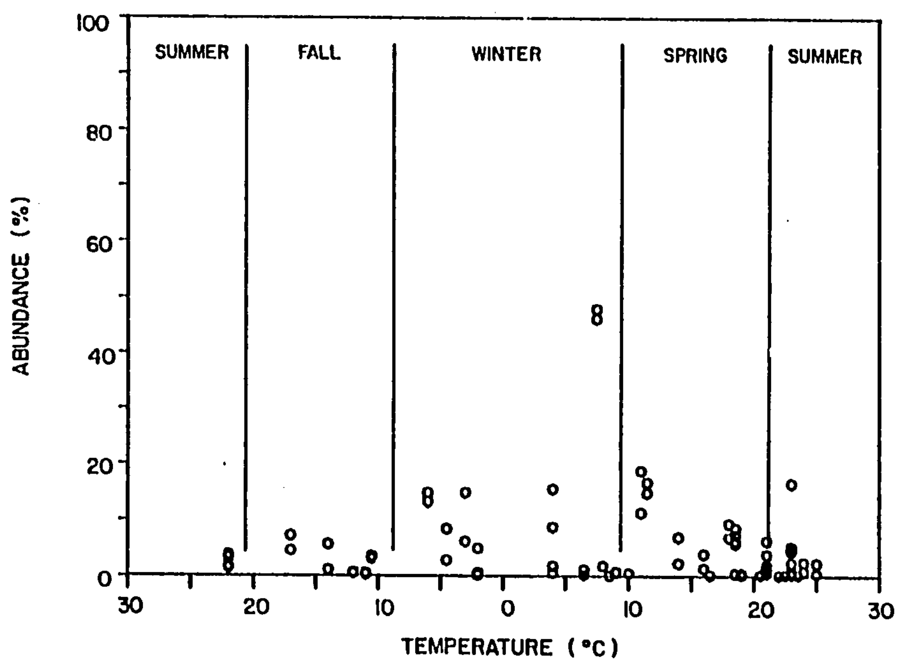

Figure 42. Abundance vs. temperature and season for populations of <u>Fragilaria vaucheria</u>

with no clear indication of periodicity or temperature preference (Figure 41).

Fragilaria vaucheriae Peters. var. vaucheriae

Plate: 10, Figs. 6 and 10.

Critical reference: Patrick and Reimer, 1966, p. 120, Pl. 3, Figs. 14 - 15.

Descriptors: Striae, 10 - 12 μm. Length, 20 - 45 μm. Breadth 3 - 5 μm.

Ecology: Freshwater streams, rivers (Hohn and Hellerman, 1963); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969); periphytic (Kolkwitz, 1914; Hustedt, 1937 - 1938; Jorgensen, 1948). Alkaliphilous (Foged, 1948, 1958, 1968a; Jorgensen, 1948). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1953, 1954, 1968a). Beta - mesosaprobic (Kolkwitz, 1914; Manguin, 1952). Current indifferent (Foged, 1948, 1954) to rheophilous (Foged, 1968a). Oligothermal (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hostetter and Stoermer, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Brewer's Creek (Edwards and Christensen, 1973). Des Moines River (Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Drainage ditches (Edwards, 1974). Subaerial habitats

(Stoermer, 1962). Epizoic (Fee and Drum, 1965). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Common in the plankton from all of the lakes (Table 91). A perennial species which is most abundant during the late fall, winter and spring (Figure 42). Oligothermal.

Fragilaria virescens Ralfs var. *virescens*

Plate: 10, Fig. 5.

Critical reference: Patrick and Reimer, 1966, p. 119, Pl. 3, Figs. 7 - 9.

Descriptors: Striae, 8 - 15 in 10 μm. Length, 20 - 38 μm. Breadth, 3 - 5 μm.

Ecology: Freshwater streams and rivers (Hustedt, 1930a; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). pH indifferent (Foged, 1953, 1954, 1964; Hustedt, 1957; Merilainen, 1967). Oligohalobous indifferent (Schroeder, 1939; Foged, 1953, 1954) to halophobous (Kolbe, 1927; Hustedt, 1957). Oligosaprobic (Hustedt, 1957). Current indifferent (Foged, 1954). Seasonal maximum - spring and fall (Schroeder, 1939).

Previous reports from Iowa: North Twin Lake (Kutkukn, 1958). Arend's Kettle Hole (Collins, 1968). Drainage ditches (Lowe, 1970; Edwards, 1974). Soil (Loescher, 1971). Cayler Prairie (Reimer, 1970).

<u>Occurrence</u>: Rare in the plankton of the Lake District (Table 92). Observed only in samples from Silver Lake and Lake West Okoboji. No clear indication of periodicity or temperature preference.

Table 92. Summary of distribution and relative abundance for <u>Fragilaria</u> <u>virescens</u> v. <u>virescens</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake							r				
West Okoboji			r								
Center Lake											
Spirit Lake											
East Okoboji											

<u>Gomphoneis</u> <u>eriense</u> (Grun.) Skv. & Myer var. <u>eriense</u>

<u>Plate</u>: 18, Fig. 20.

<u>Critical</u> <u>reference</u>: Patrick and Reimer, 1975, p. 148, Pl. 20, Fig. 3.

<u>Descriptors</u>: Striae, 12 in 10 µm. Length, 45 µm. Breadth, 12.5 µm.

<u>Ecology</u>: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Seems to prefer cool water (Patrick and Reimer, 1975).

<u>Previous</u> <u>reports</u> <u>from</u> <u>Iowa</u>: Lake West Okoboji (Stoermer, 1963a).

<u>Occurrence</u>: Rare in the plankton of Silver Lake (Table 93). No clear indication of periodicity or temperature preference.

<u>Gomphonema</u> <u>acuminatum</u> f. <u>brebisonii</u> (Kutz) P.T. Cleve

<u>Plate</u>: 17, Fig. 8.

<u>Critical</u> <u>reference</u>: Mayer, 1928, p. 94, Pl. 1, Figs. 17 - 21.

<u>Descriptors</u>: Length, 20 µm. Breadth, 5 µm. Striae, 12 in 10 µm.

<u>Ecology</u>: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1949, 1968a; Hustedt, 1957). Halobion indifferent (Petersen, 1943; Foged, 1948, 1949, 1954; Hustedt, 1957). Oligosaprobic (Hustedt, 1957). Limnophilous

Table 93. Summary of distribution and relative abundance for *Gomphoneis eriense* v. *eriense*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r						r		
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

(Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake and Ventura Marsh (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Des Moines River (Drum, 1964). Drainage ditches (Lowe, 1970).

Occurrence: Rare in a single plankton collection from Lake East Okoboji (Table 94).

Gomphonema affine Kutz. var. *affine*

Plate: 17, Fig. 9.

Critical reference: Patrick and Reimer, 1975, p. 133, Pl. 17, Fig. 5.

Descriptors: Striae, 6 - 8 in 10 µm. Length, 37 - 43 µm. Breadth, 11 µm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977). Tolerant of a wide range of conductivity in fresh water (Patrick and Reimer, 1975).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Des Moines River (Drum, 1964). Farm ponds (Ohl, 1965). Cayler Prairie (Reimer, 1970). Skunk River (Beckert, 1977).

Occurrence: Rare in the plankton of the Lake District (Table 95). Observed in only one sample from Silver Lake. No clear indication of periodicity or temperature preference.

Gomphonema angustatum (Kutz.) Rabh. var. *angustatum*

Plate: 17, Fig. 10.

Table 94. Summary of distribution and relative abundance for _Gomphonema_ _acuminatum_ f. _brebisonii_

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji							r				

Table 95. Summary of distribution and relative abundance for _Gomphonema_ _affine_ v. _affine_

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake					r						
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Critical reference: Patrick and Reimer, 1975, p. 125, Pl. 17, Figs. 17 - 19.

Descriptors: Striae, 8 - 14 in 10 µm. Length, 17 - 29 µm. Breadth, 6.3 µm.

Ecology: Freshwater streams and rivers (Hustedt, 1957; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969); periphytic (Manguin, 1952). Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1949, 1953, 1968a; Hustedt, 1957). Oligohalobous indifferent (Foged, 1948, 1953, 1968a; Scheele, 1952; Hustedt, 1957). Oligosaprobic (Kolkwitz and Marsson, 1908; Budde, 1931). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Mesothermal (Scheele, 1952; Bock, 1952) to eurythermal (Scheele, 1952.

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Des Moines River (Gudmundson, 1969). Dutch Creek (Fee, 1967). Skunk River (Roeder, 1976). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Cayler Prairie (Reimer, 1970). Soil (Loescher, 1971). Silver Lake Fen (Shobe et al., 1963). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton from several lakes (Table 96). No clear indication of periodicity.

Table 96. Summary of distribution and relative abundance for <u>Gomphonema</u> <u>angustatum</u> v. <u>angustatum</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake									c		
West Okoboji											
Center Lake											
Spirit Lake									r		
East Okoboji				r							

Table 97. Summary of distribution and relative abundance for <u>Gomphonema</u> <u>angustatum</u> v. <u>citera</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r	r	r		r				
West Okoboji				r		r					
Center Lake											
Spirit Lake			r								
East Okoboji				r							

Gomphonema angustatum var. citera

Plate: 17, Fig. 12.

Critical reference: Patrick and Reimer, 1966, p. 125, Pl. 17, Fig. 14.

Descriptors: Length, 29 µm. Breadth, 7 µm. Striae 11 in 10 µm.

Ecology: Mesotrophic to eutropic (Patrick and Reimer, 1975). Low to medium hardness (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: Observed in plankton collections from all of the Lakes except Center Lake, but always rare (Table 97).

Gomphonema angustatum var. intermedia Grun.

Plate: 17, Fig. 11.

Critical reference: Patrick and Reimer, 1966, p. 126, Pl. 17, Fig. 20.

Descriptors: Length, 21 µm. Breadth, 7 µm. Striae, 10-11 in 10 µm.

Ecology: Typically found in circumneutral to slightly alkaline freshwater (Patrick and Reimer, 1975). Oligotrophic to mesotrophic (Patrick and Reimer, 1975).

Previous reports from Iowa: Drainage ditches (Edwards, 1974).

Occurrence: Frequently encountered in a winter plankton sample from Silver Lake (Table 98).

Table 98. Summary of distribution and relative abundance for Gomphonema angustatum v. intermedia

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake	o										
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 99. Summary of distribution and relative abundance for Gomphonema clevei v. clevei

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake								r			
East Okoboji											

<u>Gomphonema</u> <u>clevei</u> Fricke var. <u>clevei</u>

<u>Plate</u>: 17, Fig. 13.

<u>Critical</u> <u>reference</u>: Patrick and Reimer, 1975, p. 138, Pl. 18, Fig. 6.

<u>Descriptors</u>: Striae, 10 - 13 in 10 µm. Length, 25.2 - 27 µm. Breadth, 4.5 - 6.3 µm.

<u>Ecology</u>: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Oligohalobous (Hustedt, 1937 - 1938).

<u>Previous</u> <u>reports</u> <u>from</u> <u>Iowa</u>: None.

<u>Occurrence</u>: Rare in one plankton sample from Spirit Lake (Table 99). No clear indication of periodicity or optimum temperature for growth.

<u>Gomphonema</u> <u>dichotomum</u> Kutz. var. <u>dichotomum</u>

<u>Plate</u>: 18, Fig. 1.

<u>Critical</u> <u>reference</u>: Patrick and Reimer, 1975, p. 135, Pl. 18, Figs. 2 - 3.

<u>Descriptors</u>: Striae, 7 in 10 µm. Length, 57 - 58 µm. Breadth, 9.2 - 9.4 µm.

<u>Ecology</u>: Freshwater streams and rivers (Collins and Kalinsky, 1977). pH indifferent (Patrick and Reimer, 1975).

<u>Previous</u> <u>reports</u> <u>from</u> <u>Iowa</u>: None.

<u>Occurrence</u>: Observed only from the plankton of Silver Lake (Table 100). Rare. No clear indication of periodicity or temperature preference.

Table 100. Summary of distribution and relative abundance for Gomphonema dichotomum Kutz. var. dichotomum

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake				r	r		r			r	
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 101. Summary of distribution and relative abundance for Gomphonema gracile v. gracile

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r				r				
East Okoboji											

Gomphonema gracile ehr. emend. V. H. var. gracile

Plate: 18, Fig. 2.

Critical reference: Patrick and Reimer, 1975, p. 131, Pl. 17, Figs. 1 - 3.

Descriptors: Striae, 12 - 13 µm. Length, 30 - 35 µm. Breadth, 6.3 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Bock, 1952). pH indifferent (Hustedt, 1937 - 1938; Jorgensen, 1948; Foged, 1954, 1964; Merilainen, 1967) to alkaliphilous (Foged, 1953, 1958; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1953, 1954; Manguin, 1952). Limnobiontic (Hustedt, 1930a; Foged, 1954) to limnophilous (Hustedt, 1930a).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Des Moines River (Drum, 1964). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Arend's Kettle Hole (Collins, 1968).

Occurrence: Rare, observed only in two collections from Spirit Lake (Table 101). No clear indication of periodicity or optimum temperature.

Gomphonema intricatum Kutz. var. intricatum

Plate: 18, Fig. 4.

Critical reference: Patrick and Reimer, 1975, p. 134,

Pl. 18, Fig. 1.

Descriptors: Striae, 7 - 13 in 10 μm. Length, 13 - 61 μm. Breadth, 3.6 - 11 μm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977); lakes and ponds (Jorgensen, 1948; Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969); periphytic (Hustedt, 1937 - 1938). Alkaliphilous (Hustedt, 1937 - 1938; Jorgensen, 1948; Foged, 1948, 1958, 1968a). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1949, 1954, 1968a; Hustedt, 1957). Saproxenous (Hustedt, 1957). Limnobiontic (Hustedt, 1930a; Foged, 1948, 1954).

Previous reports from Iowa: Lake West Okoboji (Collins, 1968). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Cayler Prairie (Reimer, 1970). Silver Lake Fen (Shobe et al., 1963). Epizoic (Fee and Drum, 1965). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton of Silver Lake and Lake West Okoboji (Table 102). No clear indication of seasonal periodicity or temperature preference.

Gomphonema intricatum var. pumila Grun.

Plate: 18, Fig. 3.

Critical reference: Hustedt, 1930a, p. 375, Fig. 699.

Descriptors: Striae, 12 in 10 μm. Length, 21 μm.

Table 102. Summary of distribution and relative abundance for *Gomphonema intricatum* v. *intricatum*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake				r				r			
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Table 103. Summary of distribution and relative abundance for *Gomphonema intricatum* v. *pumila*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Breadth, 4 μm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); Lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1970). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964). Drainage ditches (Lowe, 1970; Edwards, 1974). Cayler Prairie (Reimer, 1970). Epizoic (Fee and Drum, 1965). Arend's Kettle Hole (Collins, 1968).

Occurrence: Observed only in a single plankton sample from Lake West Okoboji (Table 103). Rare, no clear indication of periodicity.

Gomphonema intricatum var. vibrio (Ehr.) Cleve.

Plate: 18, Fig. 5.

Critical reference: Patrick and Reimer, 1975, p. 135, Pl. 18, fig. 4.

Descriptors: Striae, 6 in 10 μm. Length, 68 μm. Breadth, 11.5 μm.

Ecology: Freshwater tolerant to a fairly wide range of conductivity (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: Observed in a single plankton sample from Spirit Lake (Table 104). Rare, with no clear indication of periodicity or temperature preference.

Table 104. Summary of distribution and relative abundance for *Gomphonema intricatum* v. *vibrio*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

Gomphonema olivaceoides Hust. var. olivaceoides

Plate: 18, Fig. 6.

Critical reference: Patrick and Reimer, 1975, p. 144, Pl. 18, Figs. 21a - b.

Descriptors: Striae, 11 - 14 µm. Length, 16 - 19 µm. Breadth, 11 - 14 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969); periphytic (Hustedt, 1950). Seems to prefer cool fresh water (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: Observed only in collections from Spirit Lake and Lake East Okoboji (Table 105). Abundant during the winter, present in spring and summer plankton (Figure 43). Oligothermal.

Gomphonema olivaceum (Lyngb.) Kutz. var. olivaceum

Plate: 18, Fig. 7.

Critical reference: Patrick and Reimer, 1975, p. 139, Pl. 18, Figs. 13 - 14.

Descriptors: Striae, 11 - 13 in 10 µm. Length, 22 - 31.5 µm. Breadth, 6 - 7.5 µm.

Ecology: Freshwater lakes and ponds (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic

Table 105. Summary of distribution and relative abundance for <u>Gomphonema</u> <u>olivaceoides</u> v. <u>olivaceoides</u>

Lake	Apr 1979	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan 1980	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake		r	r	r				a			r
East Okoboji		r	r								

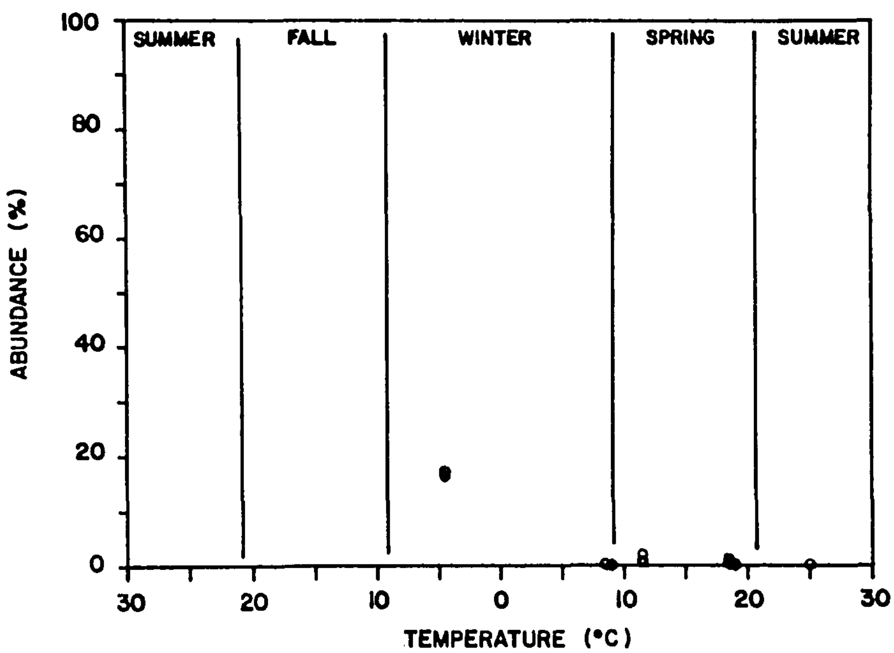

Figure 43. Abundance vs. temperature and season for populations of <u>Gomphonema</u> <u>olivaceoides</u>

(Stoermer and Yang, 1969); periphytic (Scheele, 1952; Hornung, 1959). Alkalibiontic (Jorgensen, 1948; Foged, 1948, 1949, 1954, 1968a; Hustedt, 1957; Hornung, 1959). Eutrophic (Jorgensen, 1948). pH indifferent (Petersen, 1943; Foged, 1948, 1949, 1954; Hustedt, 1957). Oligosaprobic (Hustedt, 1957; Blum, 1957) to mesosaprobic (Kolkwitz and Marsson, 1908; Fjerdingstadt, 1950). Mesothermal (Scheele, 1952) to eurythermal (Scheele, 1952). Seasonal maximum - winter (Blum, 1957) or spring (Raabe, 1951).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Clear Lake (Begres, 1971). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Coralville Reservoir (Schmidt and Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Brewer's Creek (Edwards and Christensen, 1973). Farm ponds (Ohl, 1965). Dutch Creek (Fee, 1967). Spirit Lake (Krohn et al., 1974).

Occurrence: Observed in the winter, spring, and summer plankton of Lake West Okoboji and Spirit Lake (Table 106) (Figure 44). Most abundant during the winter in Spirit Lake. Oligothermal.

Table 106. Summary of distribution and relative abundance for *Gomphonema olivaceum* v. *olivaceum*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji		r		r	r						
Center Lake											
Spirit Lake			r					c			r
East Okoboji											

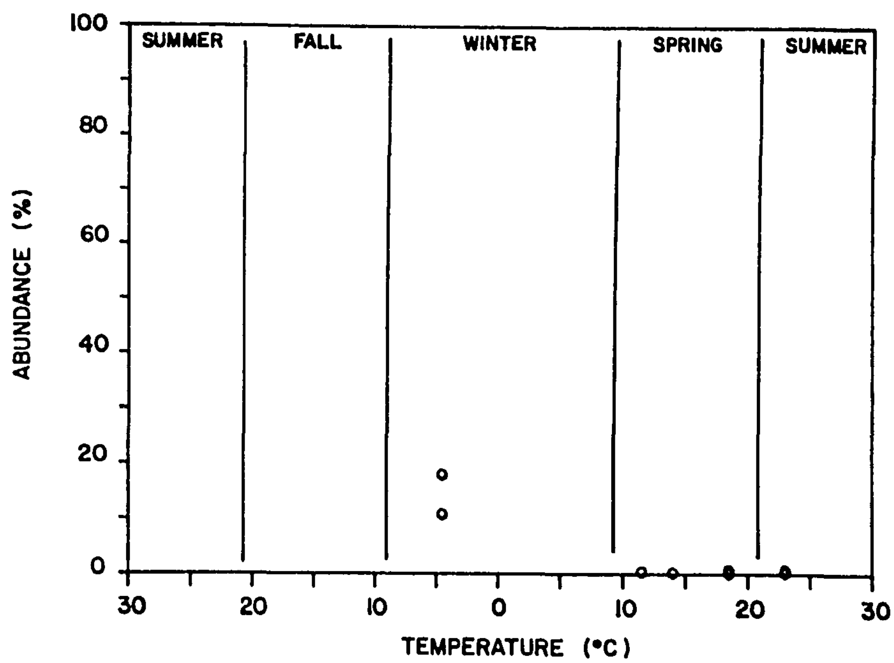

Figure 44. Abundance vs. temperature and season for populations of *Gomphonema olivaceum*

Gomphonema parvulum (Kutz.) var. parvulum

Plate: 18, Fig. 8.

Critical reference: Patrick and Reimer, 1975, p. 122, Pl. 17, Figs. 7 - 11.

Descriptors: Striae, 13 in 10 µm. Length, 17 - 20 µm. Breadth, 7 µm.

Ecology: Freshwater Lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Manguin, 1952; Scheele, 1952). pH indifferent (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1949, 1958; Scheele, 1952). Oligohalobous indifferent (Kolkwitz and Marsson, 1908; Hustedt, 1930a, 1937 - 1938; Foged, 1948, 1954, 1968a). Mesosaprobic (Kolkwitz and Marsson, 1908; Fjerdingstadt, 1950; Manguin, 1952). Rheophilous (Petersen, 1943; Foged, 1948, 1954). Mesothermal (Hustedt, 1937 - 1938; Scheele, 1952) to stenothermal (Hustedt, 1937 - 1938; Scheele, 1952).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Coralville Reservoir (Schmidt and Fee, 1967). Des Moines River (Starrett and Patrick, 1952; Drum, 1964) Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Sewage stabilization

Table 107. Summary of distribution and relative abundance for <u>Gomphonema</u> <u>parvulum</u> v. <u>parvulum</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			o		r			r			
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

ponds (Raschke, 1968). Cayler Prairie (Reimer, 1970). Subaerial habitats (Stoermer, 1962). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton of Silver Lake (Table 107). No clear indication of periodicity or temperature preference.

Gomphonema subclavatum var. *commutatum* (Grun.) A. Mayer

Plate: 18, Fig. 9.

Critical reference: Patrick and Reimer, 1975, p. 129, Pl. 16, Fig. 11.

Descriptors: Striae, 11 in 10 μm. Length, 29 μm, Breadth, 6.3 μm.

Ecology: Freshwater seems to prefer moderately hard water (Patrick and Reimer, 1965).

Previous reports from Iowa: None.

Occurrence: A rare form collected only from Silver Lake (Table 108). No clear indication of periodicity or temperature preference.

Gomphonema subclavatum var. *mexicanum* (Grun.) Patr.

Plate: 18, Fig. 10.

Critical reference: Patrick and Reimer, 1975, p. 130, Pl. 16, Figs. 12 - 13.

Descriptors: Striae, 10 - 12 in 10 μm. Length, 30 -

Table 108. Summary of distribution and relative abundance for <u>Gomphonema</u> <u>subclavatum</u> v. <u>commutatum</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r								
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 109. Summary of distribution and relative abundance for <u>Gomphonema</u> <u>subclavatum</u> v. <u>mexicanum</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			o	r			r	r			
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji				r							

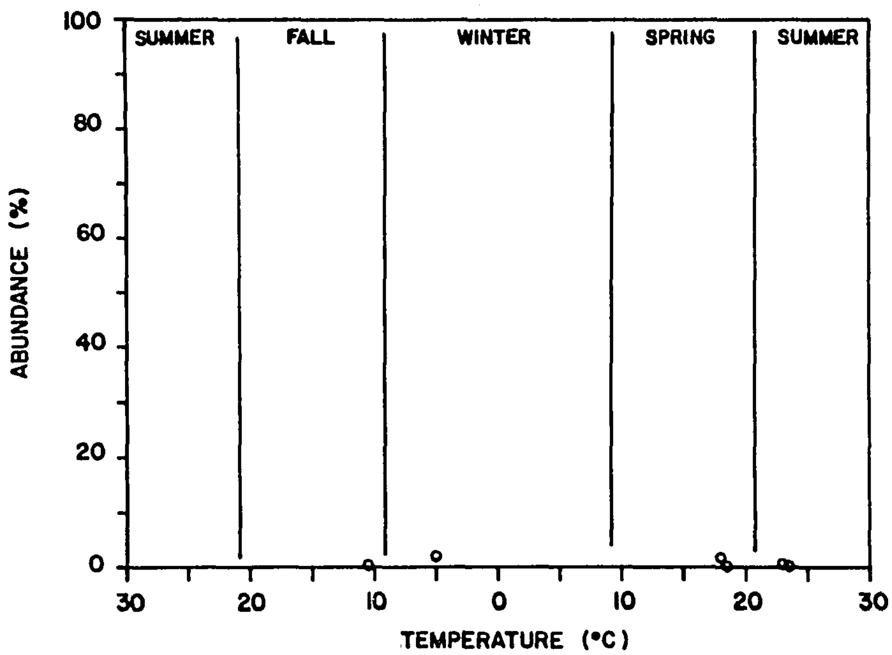

Figure 45. Abundance vs. temperature and season for populations of Gomphonema subclavatum v. mexicanum

34 μm. Breadth, 6 - 8 μm.

Ecology: Freshwater seems to prefer warm water of medium hardness (Patrick and Reimer, 1975).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Arend's Kettle Hole (Collins, 1968).

Occurrence: Perennial form, collected during all seasons (Table 109). Always, rare with no clear indication of periodicity. Temperature indifferent (Figure 45).

Gomphonema truncatum Ehr. var. *truncatum*

Plate: 18, Fig. 11.

Critical reference: Patrick and Reimer, 1975, p. 118, Pl. 16, Fig. 3.

Descriptors: Striae, 12 in 10 μm. Length, 36 μm. Breadth, 9 μm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977). Prefers circumneutral water with moderate hardness; tolerates a wide range of cool to moderately warm waters, preferes water of low to moderate nutrient content (Patrick and Reimer, 1975).

Previous reports from Iowa: Skunk River (Beckert, 1977).

Occurrence: Observed in a single spring plankton sample from Center Lake (Table 110). No clear indication of

Table 110. Summary of distribution and relative abundance for Gomphonema truncatum v. truncatum

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											r
Spirit Lake											
East Okoboji											

Table 111. Summary of distribution and relative abundance for Gomphonema tergestinium v. tergestinium

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji										o	
Center Lake											
Spirit Lake											
East Okoboji											

periodicity or temperature preference.

Gomphonema tergestinium (Grun.) Fricke var. tergestinium

Critical reference: Patrick and Reimer, 1975, p. 136, Pl. 18, Fig. 5.

Descriptors: Central area broad, transverse. Striae radiate throughout, except parallel at the apex. Striae 12 - 13 in 10 µm. Length, 30 µm. Breadth, 6 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969; Patrick and Reimer, 1975). Euplanktonic (Stoermer and Yang, 1969). Prefers cool waters (oligothermal) (Patrick and Reimer, 1975).

Previous reports from Iowa: None.

Occurrence: Observed in a single plankton sample from Lake West Okoboji (Table 111. No clear indication of periodicity or optimum temperature range.

Gomphonema sp. 1

Plate: 18, Fig. 12.

Descriptors: Length, 26-29 µm. Breadth, 6-6.5 µm. Striae, 11 in 10 µm.

Occurrence: Rare in the plankton of Silver Lake and Lake East Okoboji (Table 112).

Gomphonema sp. 2

Plate: 18, Fig. 13.

Descriptors: Length, 19 µm. Breadth, 6 µm. Striae,

Table 112. Summary of distribution and relative abundance for *Gomphonema* sp. 1

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r								
West Okoboji											
Center Lake											
Spirit Lake								r			
East Okoboji			r								

Table 113. Summary of distribution and relative abundance for *Gomphonema* sp. 2

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake		r									
East Okoboji			r								

11 in 10 µm.

Occurrence: Rare in the plankton of Spirit Lake and Lake East Okoboji (Table 113).

Gomphonema sp. 3

Plate: 19, Fig. 1.

Descriptors: Length, 26-40 µm. Breadth, 8.5-9 µm. striae, 7-8 in 10 µm.

Occurrence: Rare in the plankton of lakes West and East Okoboji (Table 114). Rare but present in all seasons from Silver Lake. Perennial species, no clear indication of optimum temperature (Figure 46).

Gomphonema sp. 4

Plate: 18, Fig. 16.

Descriptors: Length, 24 µm. Breadth, 7 µm. Striae, 11 in 10 µm.

Occurrence: Rare in the plankton of Lake East Okoboji (Table 115).

Gomphonema sp. 5

Plate: 18, Fig. 14.

Descriptors: Length, 20 µm. Breadth, 6 µm. Striae, 15 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 116).

Table 114. Summary of distribution and relative abundance for Gomphonema sp. 3

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		r	r	o	r	r	r	r	r	o	r
West Okoboji									r		c
Center Lake											
Spirit Lake											
East Okoboji											r

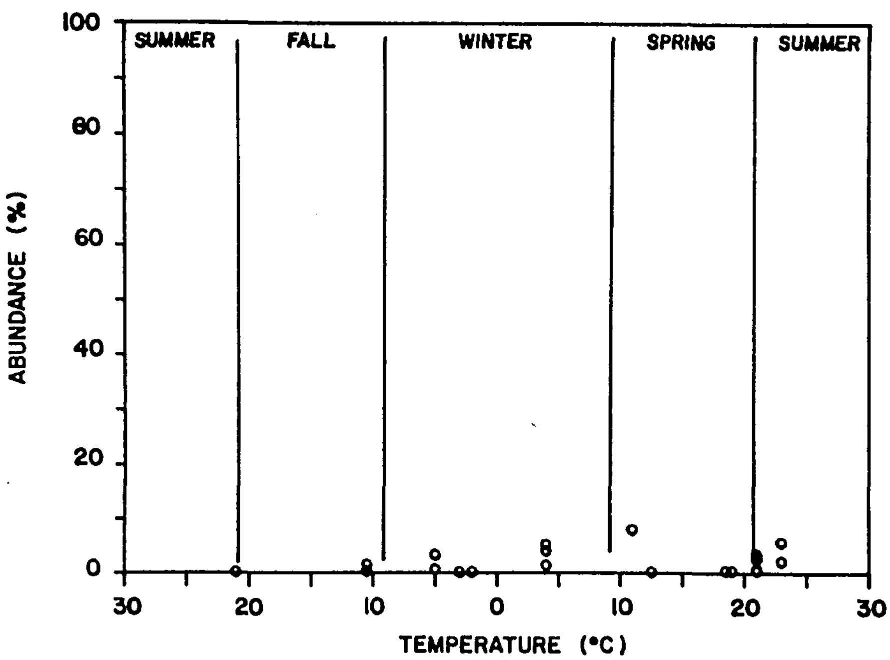

Figure 46. Abundance vs. temperature and season for populations of Gomphonema sp. 3

Table 115. Summary of distribution and relative abundance for *Gomphonema* sp. 4

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				r							

Table 116. Summary of distribution and relative abundance for *Gomphonema* sp. 5

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji							r				

Table 117. Summary of distribution and relative abundance for *Gomphonema* sp. 6

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r							
West Okoboji					r		r				
Center Lake				r							
Spirit Lake											
East Okoboji							r				

Gomphonema sp. 6

Plate: 18, Fig. 17.

Descriptors: Length, 16-20 µm. Breadth, 4-5 µm. striae, 12-14 in 10 µm.

Occurrence: Rare in the plankton of Silver Lake, lakes East and West Okoboji, and Center Lake (Table 117). No clear indication of periodicity.

Gomphonema sp. 7

Plate: 18, Fig. 15.

Descriptors: Length, 20-28 µm. Breadth, 5-6 µm. Striae, 10 in 10 µm.

Occurrence: Rare in a single plankton sample from Silver Lake (Table 118).

Gomphonema sp. 8

Plate: 18, Fig. 19.

Descriptors: Length, 60 µm. Breadth, 10.5 µm. Striae, 10 in 10 µm.

Occurrence: Rare in a single plankton sample from Silver Lake (Table 119).

Gomphonema sp. 9

Plate: 19, Fig. 2.

Descriptors: Length, 48 µm. Breadth, 9 µm. Striae, 10 in 10 µm.

Table 118. Summary of distribution and relative abundance for *Gomphonema* sp. 7

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake							r				
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 119. Summary of distribution and relative abundance for *Gomphonema* sp. 8

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake									r		
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 120. Summary of distribution and relative abundance for <u>Gomphonema</u> sp. 9

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake									r	r	
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 121. Summary of distribution and relative abundance for <u>Gomphonema</u> sp. 10

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r	r				r		
Center Lake											
Spirit Lake			r	r			r				
East Okoboji											

Occurrence: Rare in the plankton of Silver Lake (Table 120).

Gomphonema sp. 10

Plate: 19, Fig. 3.

Descriptors: Length, 27 µm. Breadth, 4.5 µm. Striae, 9 in 10 µm.

Occurrence: Rare in the plankton of the Region (Table 121). Observed in several samples from Lake West Okoboji and Spirit Lake.

Gomphonema sp. 11

Plate: 18, Fig. 18.

Descriptors: Length, 10.5 µm. Breadth, 4 µm. Striae, 13 in 10 µm.

Occurrence: Rare in the plankton of Lake West Okoboji and Spirit Lake (Table 122).

Gyrosigma attenuatum (Kutz.) Rabh. var. attenuatum

Plate: 14, Figs. 1 and 10.

Critical reference: Patrick and Reimer, 1966, P. 319, Pl. 24, Fig. 1.

Descriptors: Transverse striae, 14 - 15 in 10 µm; longitudinal striae, 10 - 12 in 10 µm. Length, 144 - 306 µm. Breadth, 18 - 31.5 µm.

Ecology: Freshwater streams and rivers (Collins and

Table 122. Summary of distribution and relative abundance for <u>Gomphonema</u> sp. 11

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r	r						
Center Lake											
Spirit Lake											r
East Okoboji											

Table 123. Summary of distribution and relative abundance for <u>Gyrosigma</u> <u>attenuatum</u> v. <u>attenuatum</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake			r	r							
East Okoboji											

Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous, appears to have a widespread distribution; can withstand slight salt intrusion (Patrick and Reimer, 1966). Current indifferent (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hostetter and Stoermer, 1968; Collins, 1968; Hosseini, 1979). North Twin Lake (Kutkukn, 1958). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Soil (Loescher, 1971).

Occurrence: Rare in the plankton of Lake West Okoboji and Spirit Lake (Table 123). No clear indication of periodicity or temperture preference.

Gyrosigma sciotense (Sulliv. and Wormley) Cl. var. sciotense

Plate: 13, Fig. 7 and 9.

Critical reference: Patrick and Reimer, 1966, p. 320, Pl. 24, Fig. 5.

Descriptors:

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Patrick and Reimer, 1966).

Previous reports from Iowa: Spirit lake (Krohn et al. 1974).

Occurrence: Rare (Table 124). Observed in a single plankton sample from Lake East Okoboji.

Gyrosigma spencerii (Quek.) Griff. & Henfr. var. spencerii

Plate: 13, Fig. 10 and 11.

Critical reference: Patrick and Reimer, 1966, p. 315, Pl. 23, Fig. 4.

Descriptors: Transverse striae, 18 - 20 in 10 µm; longitudinal striae, 22 - 24 in 10 µm. Length, 100 - 107 µm. Breadth, 14 - 16 µm.

Ecology: Freshwater streams and rivers (Manguin, 1952; Patrick and Reimer, 1966; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969); periphytic (Manguin, 1952). Alkaliphilous (Niessen, 1956; Hustedt, 1957; Foged, 1964) to alkalibiontic (Cholnoky, 1968; Foged, 1968a). Mesohalobous (Hustedt, 1930a, 1957; Foged, 1949, 1964; Cholnoky, 1968) to oligohalobous indifferent (Manguin, 1952; Patrick and Reimer, 1966; Foged, 1968a). Oligosaprobic (Hustedt, 1957). Current indifferent (Foged, 1948).

Previous reports from Iowa: Clear Lake (Begres, 1971). West Lake Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Coraville Reservoir (Schmidt and Fee, 1967). Des Moines River (Gudmundson, 1969). Dutch Creek (Fee, 1967). Skunk River (Roeder, 1976; Beckert, 1977).

Occurrence: Observed in a single plankton sample from Center Lake (Table 125). Rare, with no clear indication of

Table 124. Summary of distribution and relative abundance for <u>Gyrosigma</u> <u>sciotense</u> v. <u>sciotense</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji								r			

Table 125. Summary of distribution and relative abundance for <u>Gyrosigma</u> <u>spencerii</u> v. <u>spencerii</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake				r							
Spirit Lake											
East Okoboji											

periodicity or optimum temperature for occurrence.

Gyrosigma sp. 1

Plate: 14, Fig. 11.

Descriptors: Length, 261 µm. breadth, 28 µm. Transverse striae, 11 in 10 µm. Longitudinal striae, 10 in 10 µm.

Occurrence: Rare, observed only in a single plankton sample from lake east Okoboji (Table 126).

Melosira ambigua (Grun.) O. Muller var. ambigua

Plate: 1, Fig. 7.

Critical reference: Hustedt, 1930a, p. 89, Fig. 49.

Descriptors: Diameter, 4 - 15 µm. Height, 3.5 - 13 µm. Pseudosulkus a distinct furrow.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977); lakes (Hustedt, 1930a, 1937 - 1938, 1949). Euplanktonic (Hustedt, 1930a, 1937 - 1938, 1949). pH indifferent (Foged, 1948, 1954, 1958) to alkaliphilous (Hustedt, 1957; Merilainen, 1967; Foged, 1968a). Eutrophic (Hustedt, 1930a, 1937 - 1938, 1949, 1957). Oligohalobous indifferent (Foged, 1948, 1954, 1968a). Oligosaprobic (Kolkwitz and Marsson, 1908; Hustedt, 1957). Current indifferent (Hustedt, 1930a; Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres,

Table 126. Summary of distribution and relative abundance for <u>Gyrosigma</u> sp. 1.

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji								r			

Table 127. Summary of distribution and relative abundance for <u>Melosira</u> <u>ambigua</u> v. <u>ambigua</u>

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake		r		r		r		r			
West Okoboji							r				
Center Lake		c		o	o	o	r	r			
Spirit Lake											
East Okoboji				r	r	r	r				

1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968. Lake East Okoboji (Volker, 1963). North Twin Lake (Kutkukn, 1958). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Arend's Kettle Hole (Collins, 1968).

Occurrence: Rare in plankton samples from all of the lakes except Spirit Lake (Table 127). Perennial entity found during all seasons (Figure 47). Temperature indifferent.

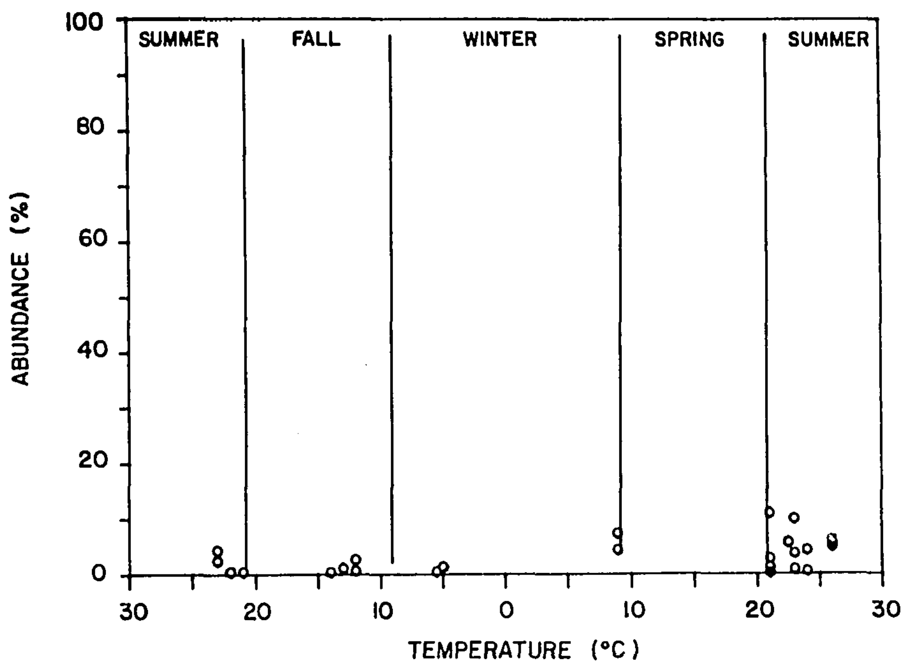

Figure 47. Abundance vs. temperature and season for populations of Melosira ambigua

Melosira granulata (Ehr.) Ralfs var. granulata

Plate: 1, Fig. 3 and 5.

Critical reference: Hustedt, 1930a, p. 87, Fig. 44.

Descriptors: Diameter, 5 - 21 µm. Height, 5 - 18 µm.

Ecology: Freshwater lakes and ponds (Jorgensen, 1948; Hustedt, 1957; Foged, 1964; Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Foged, 1964; Collins and Kalinsky, 1977). Euplanktonic (Hustedt, 1930a, 1937 - 1938, 1949, 1957; Foged 1964; Stoermer and Yang, 1969). Alkaliphilous (Jorgensen, 1948; Foged 1948, 1954, 1958, 1968a; Cholnoky, 1968). Eutrophic (Hustedt, 1937 - 1938, 1957; Jorgensen, 1948; Foged, 1964). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Manguin, 1952). Oligosaprobic (Kolkwitz, 1914; Kolkwitz and Marsson, 1908) to mesosaprobic (Fjerdingstadt, 1950). Limnophilous (Foged, 1948, 1954). Seasonal maximum - summer (Hustedt, 1930a).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Lake East Okoboji (Volker, 1963). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Coraville Reservoir (Schmidt and Fee, 1967). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Farm ponds (Ohl, 1965). Drainage ditches (Edwards, 1974). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Common in all the lakes (Table 128). Greatest abundance observed during the spring, summer, and fall (Figure 48). Mesothermal.

Table 128. Summary of distribution and relative abundance for Melosira granulata v. granulata

Lake	Apr 1979	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan 1980	Mar	Apr
Silver Lake		r	r	r	o	r	r				
West Okoboji		r	r	o	a	a	c	r			r
Center Lake	r	r	c	c	c	a	a	r			o
Spirit Lake		r		c	o	r	r	r		r	
East Okoboji		r	r	r	o	r	r				

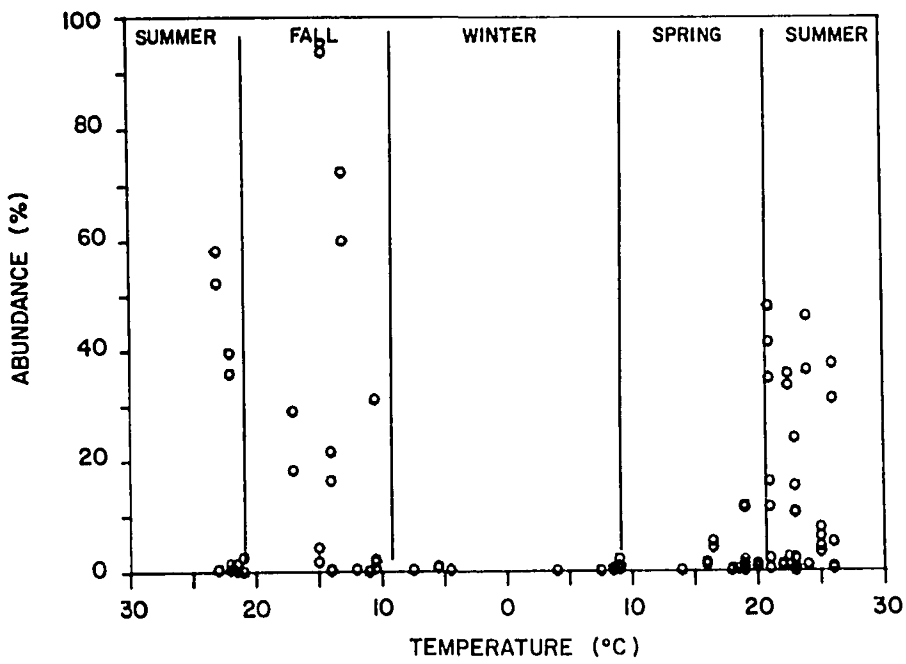

Figure 48. Abundance vs. temperature and season for populations of Melosira granulata

Melosira granulata var. angustissima O. Muller

Plate: 1, Fig. 6.

Critical reference: Hustedt, 1930a, p. 88, Fig. 45.

Descriptors: Diameter, 3 - 5 µm. Length, 13.5 - 27 µm. Length to breadth ratio usually 10 or greater.

Ecology: Freshwater lakes and ponds (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Jorgensen, 1948; Hustedt, 1949; Manguin, 1952; Stoermer and Yang, 1969). Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1954; 1968a; Hustedt, 1957). Eutrophic (Jorgensen, 1948; Hustedt, 1949, 1957). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Manguin, 1952). Mesosaprobic (Fjerdingstadt, 1950). Limnobiontic (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Coraville Reservoir (Schmidt and Fee, 1967). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Farm ponds (Ohl, 1965). Epizoic (Fee and Drum, 1965). Skunk River (Beckert, 1977).

Occurrence: This entity is less common than the nominate variety but follows the same pattern of occurrence (Table 129). Not observed in Silver Lake. Collected during

Table 129. Summary of distribution and relative abundance for <u>Melosira granulata</u> v. <u>angustissima</u>

	1979								1980		
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				c	c	c	o	r		r	
Center Lake				r	c	c	c	a	r		o
Spirit Lake		o	r	o	c	r					
East Okoboji				o	r	o		r			

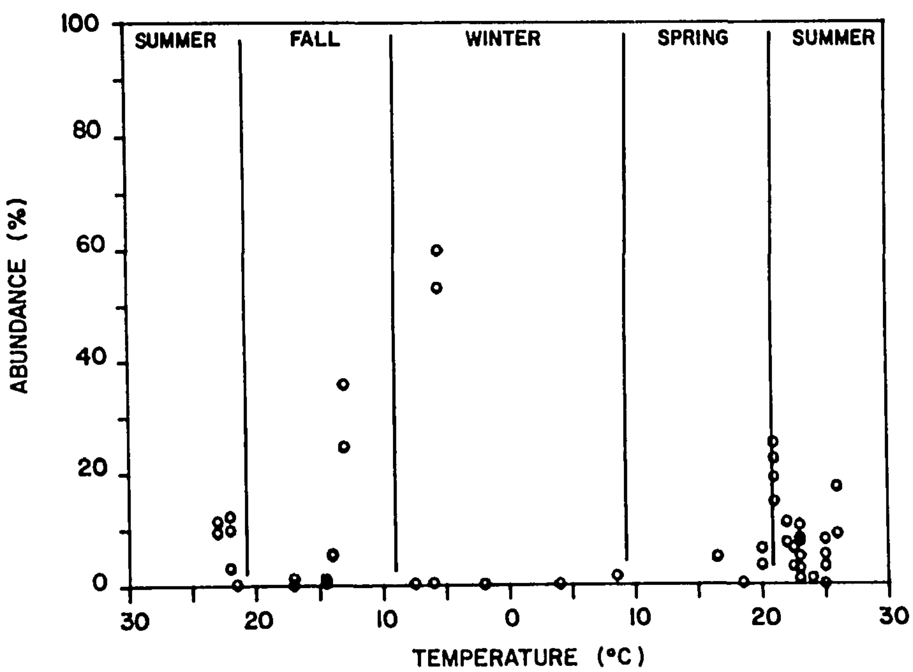

Figure 49. Abundance vs. temperature and season for populations of <u>Melosira granulata</u> v. <u>angustissima</u>

all seasons (Figure 49). Mesothermal.

Melosira islandica O. Muller var. islandica

Plate: 1, Fig. 1.

Critical reference: Hustedt, 1930a, p. 88, Fig. 48.

Descriptors: Diameter, 7 - 25 µm. Height, 4 - 20 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1954, 1958). Eutrophic (Hustedt, 1930a) to oligotrophic (Hustedt, 1930a). Oligohalobous indifferent (Petersen, 1943; Foged, 1968a). Seasonal maximum - spring and fall (Hustedt, 1930a).

Previous reports from Iowa: None.

Occurrence: Rare entity found only in fall collections from Lake East Okoboji, with other species of Melosira (Table 130). Mesothermal.

Melosira italica (Ehr.) Kutz. var. italica

Plate: 1, Fig. 2.

Critical reference: Hustedt, 1930a, p. 91, Fig. 50.

Descriptors: Diameter, 5 - 25 µm. Height, 8 - 21 µm.

Ecology: Freshwater streams and rivers (Hustedt, 1930a; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes and ponds (Hustedt, 1930a). Tychoplanktonic (Manguin, 1952; Foged, 1964); periphytic (Hustedt, 1930a, 1949; Foged, 1964).

Table 130. Summary of distribution and relative abundance for *Melosira islandica* v. *islandica*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji						o	o				

Table 131. Summary of distribution and relative abundance for *Melosira italica* v. *italica*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake	o	a	a	c	r		r	r			r
East Okoboji							r				r

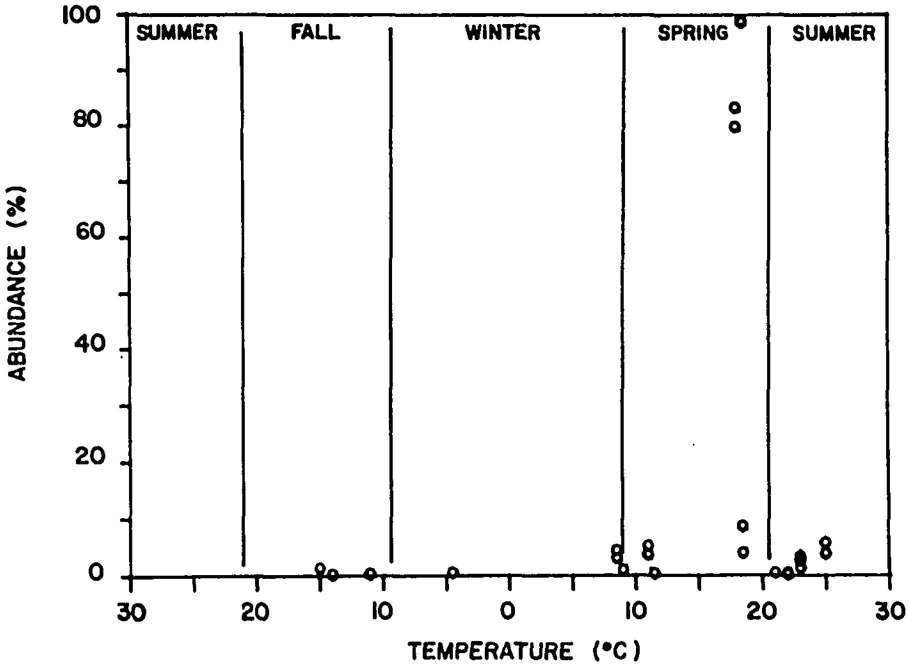

Figure 50. Abundance vs. temperature and season for populations of Melosira italica

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Lake East Okoboji (Volker, 1963). Des Moines River (Gudmundson, 1969). Spirit Lake (Krohn et al., 1974).

Occurrence: Perennial form observed during all seasons (Figure 50). Most abundant during the spring in Spirit Lake (Table 131). Mesothermal.

Melosira varians Agardh var. varians

Plate: 1, Fig. 4.

Critical reference: Hustedt, 1930a, p. 87, Fig. 41.

Descriptors: Diameter, 10 - 13.5 µm. Height, 10 - 13.5 µm.

Ecology: Freshwater streams and rivers (Hustedt, 1930a; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes and ponds (Hustedt, 1930a; Scheele, 1952; Stoermer and Yang, 1969). Euplanktonic (Hustedt, 1930a; Stoermer and Yang, 1969); tychoplanktonic (Manguin, 1952); periphyton (Hustedt, 1937 - 1938, 1957; Hornung, 1959). Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1954, 1968a; Hustedt, 1957; Hornung, 1959). Eutrophic (Hustedt, 1930a, 1937 - 1938; Jorgensen, 1948; Hornung, 1959; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1948, 1949, 1954, 1968a; Manguin, 1952; Scheele, 1952). Beta - mesosaprobic (Kolkwitz and Marsson, 1908; Hustedt, 1930a, 1937 - 1938). Current indifferent (Foged, 1948, 1954). Eurythermal to mesothermal (Scheele, 1952).

Table 132. Summary of distribution and relative abundance for Melosira varians v. varians

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r		r				r		
West Okoboji		r		r	r	r		r	r	r	
Center Lake											
Spirit Lake											
East Okoboji	r					r	o	r			

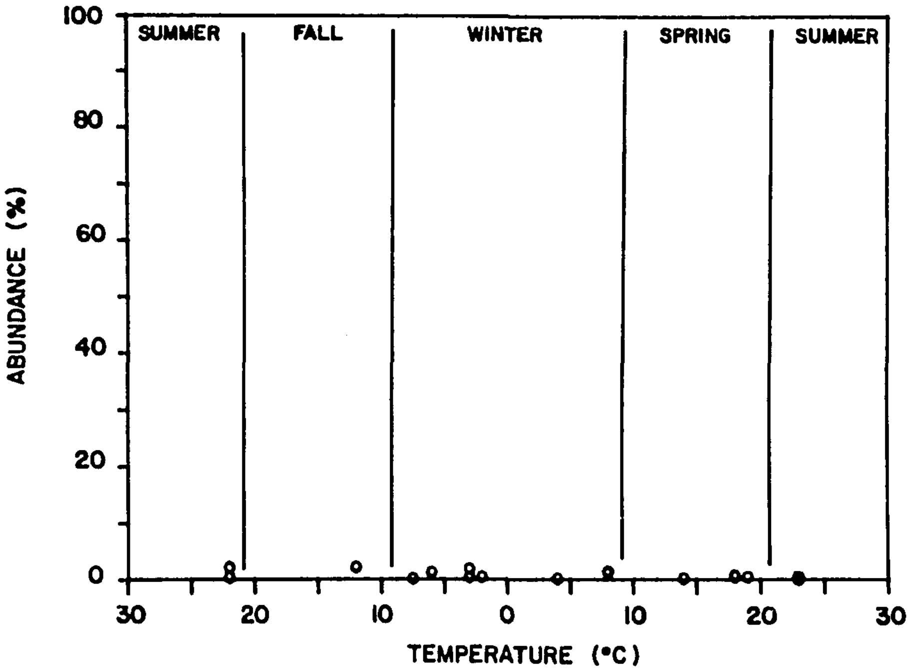

Figure 51. Abundance vs. temperature and season for populations of Melosira varians

Seasonal maximum - summer (Schroeder, 1939; Raabe, 1951; Blum, 1957).

Occurrence: Rare in the plankton of Silver Lake, Lake West Okoboji and Lake East Okoboji (Table 132). A perennial species occurring during all seasons (Figure 51). No clear indication of periodicity. Temperature indifferent.

Meridion circulare (Grev.) Agardh var. *circulare*

Plate: 9, Fig. 1.

Critical reference: Patrick and Reimer, 1966, p. 113, Pl. 2, Fig. 15.

Descriptors: Striae, 14 - 16 in 10 µm. Costae, 5 - 6 in 10 µm. Length, 15 µm. Breadth, 4 - 5 µm.

Ecology: Freshwater lakes and ponds (Jorgensen, 1948; Foged, 1964; Stoermer and Yang, 1969); streams and rivers (Jorgensen, 1948; Hornung, 1959; Foged, 1964; Collins and Kalinsky, 1977). Periphytic (Schroeder, 1939); tychoplanktonic (Schroeder, 1939); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1953, 1964, 1968a; Hustedt, 1957). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Petersen, 1943; Foged, 1948, 1953, 1968a). Oligosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914; Fjerdingstadt, 1950). Rheobiontic (Foged, 1948, 1954; Hornung, 1959) to rheophilous (Hustedt, 1937 - 1938, 1957). Eurythermal and oligothermal to mesothermal (Scheele, 1952). Seasonal maximum - spring

(Schroeder, 1939).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964). Spirit Lake (Krohn et al., 1974). Skunk River (Berkert, 1977). Brewer's Creek (Edwards and Christensen, 1973). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Soil (Loescher, 1971). Cayler Prairie (Reimer, 1970). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare, collected in a single spring plankton sample from Silver Lake (Table 133). No clear indication of periodicity or temperature preference.

Table 133. Summary of distribution and relative abundance for *Meridion circulare* v. *circulare*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake										r	
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Meridion circulare var. constricta (Ralfs.) V.H.

Plate: 9, Fig. 2.

Critical reference: Hustedt, 1930a, p. 131, Fig. 119.

Descriptors: Striae, 15 - 16 in 10 µm. Costae, 3 - 5 in 10 µm. Length, 47 µm. Breadth, 7 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Des Moines River (Gudmundson, 1969). Cayler Prairie (Reimer, 1970).

Occurrence: Rare, occurring in a single spring plankton sample from Lake West Okoboji (Table 134). No clear indication of periodicity or temperature preference.

Navicula biconica Patr. var. biconica

Plate: 15, Fig. 1.

Critical reference: Patrick and Reimer, 1966, p. 469, Pl. 44, Fig. 8.

Descriptors: Striae, 26 in 10 µm. Length, 12.6 µm. Breadth, 5.5 µm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977). pH indifferent (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Collins, 1968). Des Moines River (Drum, 1964). Drainage ditches (Lowe, 1970). Skunk River (Roeder, 1976).

Table 134. Summary of distribution and relative abundance for <u>Meridion</u> <u>circulare</u> v. <u>constricta</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji		r									
Center Lake											
Spirit Lake											
East Okoboji											

Table 135. Summary of distribution and relative abundance for <u>Navicula</u> <u>biconica</u> v. <u>biconica</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake					r						
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Occurrence: Rare in the plankton of Silver Lake (Table 135). No clear indication of periodicity.

Navicula capitata Ehr. var. capitata

Plate: 15, Fig. 2.

Critical reference: Patrick and Reimer, 1966, p. 536, Pl. 52, Figs. 1 - 2.

Descriptors: Striae, 8 - 9 in 10 µm. Length, 12 - 22.5 µm. Breadth, 4.5 - 6 µm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977); Lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Collins, 1968). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Brewer's Creek (Edwards and Christensen, 1973). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Perennial species observed during all seasons (Table 136) (Figure 52). Rare in the plankton of Silver Lake, Spirit Lake, and Lake East Okoboji. Temperature indifferent.

Navicula capitata var. hungarica (Grun.) Ross

Plate: 15, Fig. 3.

Table 136. Summary of distribution and relative abundance for *Navicula capitata* v. *capitata*

Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
			1979							1980	
Silver Lake			r	r	r		r			r	
West Okoboji											
Center Lake											
Spirit Lake			r				r				
East Okoboji			r								

Table 137. Summary of distribution and relative abundance for *Navicula capitata* v. *hungarica*

Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
			1979							1980	
Silver Lake			r	o	r	r					
West Okoboji											
Center Lake											
Spirit Lake			r				r				
East Okoboji											

Critical reference: Patrick and Reimer, 1966, p. 537, Pl. 52, Fig. 3.

Descriptors: Striae, 11 in 10 µm. Length, 12 µm. Breadth, 5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Hustedt, 1937 - 1938). Alkaliphilous (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1949, 1958; Cholnoky, 1968). Oligohalobous indifferent (Hustedt, 1937-1938, 1957; Petersen, 1943; Foged, 1948, 1949, 1954). Oligosaprobic (Kolkwitz and Marsson, 1908; Hustedt, 1957). Rheophilous (Foged, 1948, 1954; Scheele, 1952). Eurythermal and oligothermal to mesothermal (Scheele, 1952).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Beckert, 1977). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965). East Lake Okoboji (Volker, 1963). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: A rare form observed during the summer and fall in Silver Lake and Spirit Lake (Table 137).

Navicula cocconeiformis Greg. ex. Grev. var. *cocconeiformis*

Plate: 15, Fig. 4.

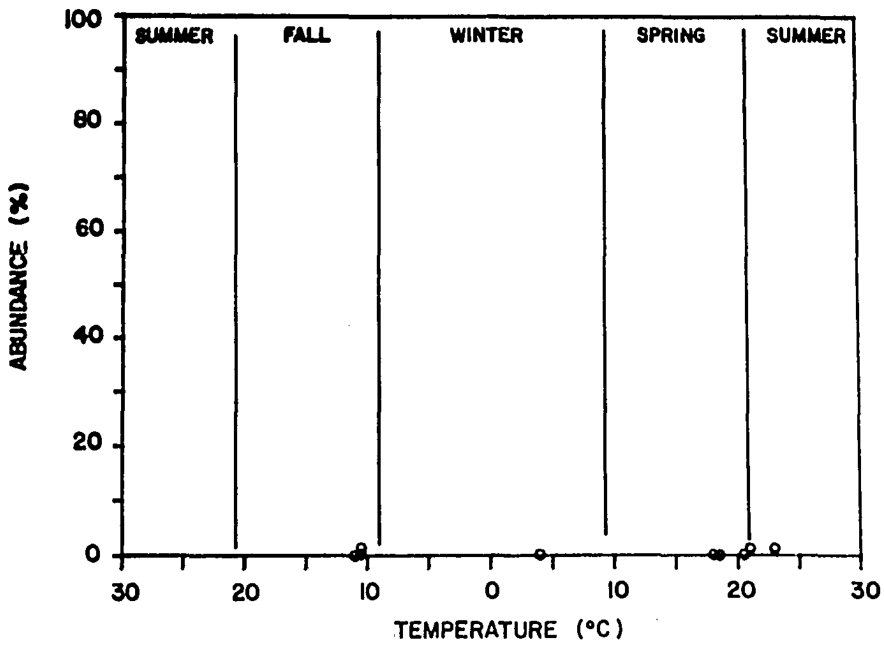

Figure 52. Abundance vs. temperature and season for populations of Navicula capitata

Critical reference: Patrick and Reimer, 1966, p. 451, Pl. 41, Fig. 5.

Descriptors: Length, 17 μm. breadth, 6 μm. Striae, 21 in 10 μm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Halobion indifferent to halophobe (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake and Ventura Marsh (Begres, 1971). Lake West Okoboji (Collins, 1968). des Moines River (Drum, 1964). Drainage ditches (Edwards, 1974).

Occurrence: Rare (Table 138). Collected only in a single plankton sample from both silver lake and Lake West Okoboji.

Navicula cryptocephala Kutz. var. *cryptocephala*

Plate: 15, Fig. 16.

Critical reference: Patrick and Reimer, 1966, p. 503, Pl. 48, Fig. 3.

Descriptors: Striae, 13 - 15 in 10 μm. Length, 25 - 37 μm. Breadth, 6 - 8 μm.

Ecology: Freshwater lakes (Patrick and Reimer, 1966; Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Patrick and Reimer, 1966; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Table 138. Summary of distribution and relative abundance for *Navicula cocconeiformis* v. *cocconeiformis*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake							r				
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Table 139. Summary of distribution and relative abundance for Navicula cryptocephala v. cryptocephala

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r				r	r		r
Center Lake						r					
Spirit Lake			r	r			r	r			
East Okoboji				r							

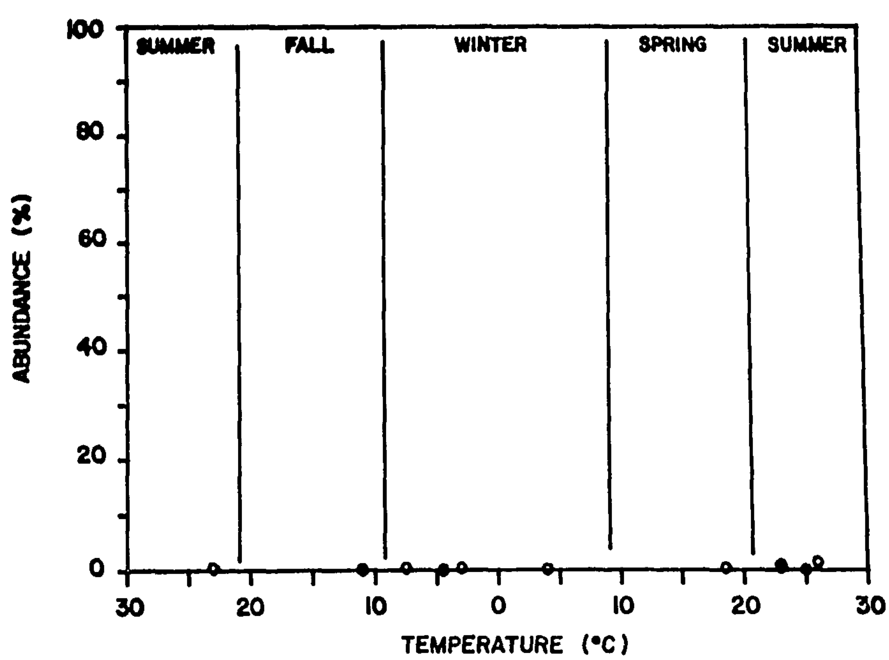

Figure 53. Abundance vs. temperature and season for populations of Navicula cryptocephala

Alkaliphilous (Foged, 1948, 1953, 1968a; Jorgensen, 1948; Cholnoky, 1968). Eutrophic (Cholnoky, 1968). Oligohalobous indifferent (Foged, 1949, 1954, 1968a; Hustedt, 1957). Beta-mesosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914; Cholnoky, 1968). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Eurythermal and oligothermal to mesothermal (Scheele, 1952). Seasonal maximum - spring (Schroeder, 1939); summer (Blum, 1957); fall (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). North Twin Lake (Kutkukn, 1958). Des Moines River (Drum, 1964). Skunk River (Roeder, 1976). Spirit Lake (Krohn et al., 1974). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Epizoic (Fee and Drum, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Perennial species collected in all seasons, always rare (Figure 53). Observed in samples from all the lakes except Silver Lake (Table 139). Optimum temperature of occurrence unknown. Range of tolerance 0° - 25° C.

Navicula cryptocephala var. *veneta* (Kutz.) Rabh.

Plate: 15, Fig. 5.

Critical reference: Patrick and Reimer, 1966, p. 504, Pl. 48, Fig. 5.

Descriptors: Striae, 15 - 16 in 10 µm. Length, 14 -

18 µm. Breadth, 5.4 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hustedt, 1937 - 1938; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1958, 1968a; Jorgensen, 1948; Hustedt, 1957). Eutrophic (Jorgensen, 1948). Euryhalobous (Budde, 1931; Foged, 1948). Rheobiontic (Foged, 1948, 1954).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Drainage ditches (Lowe, 1970; Edwards, 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965). Arend's Kettle Hole (Collins, 1968).

Occurrence: More common than the nominate variety (Table 140). Observed in plankton samples from all the lakes, always rare. Collectd during all the seasons (Figure 54). Optimum temperature of occurrence unknown. Range of tolerance 0°- 25°C.

Table 140. Summary of distribution and relative abundance for *Navicula cryptocephala* v. *veneta*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r		r	r		r			
West Okoboji				o	r		r	r	o	r	
Center Lake				r							
Spirit Lake	r	r	r	r			r	r	r		r
East Okoboji			r	o		r	r	r			

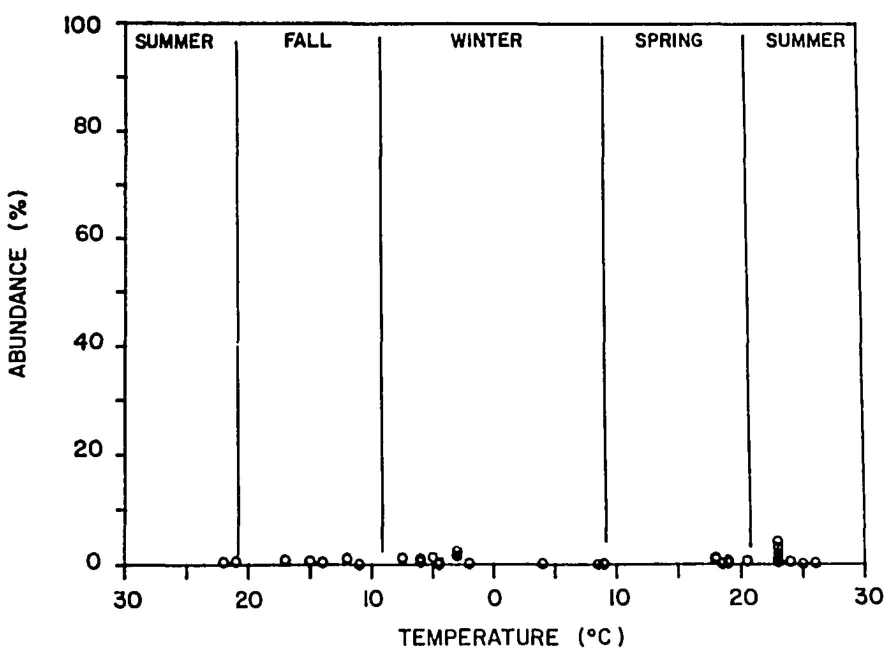

Figure 54. Abundance vs. temperature and season for populations of *Navicula cryptocephala* v. *veneta*

Navicula cuspidata (Kutz.) Kutz. var. cuspidata

Plate: 14, Fig. 3.

Critical reference: Patrick and Reimer, 1966, p. 464, Pl. 43, Figs. 9 - 10.

Descriptors: Transverse striae, 16 - 20 in 10 µm; longitudinal lines, 22 - 25 in 10 µm. Length, 100 - 160 µm. Breadth, 33 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1930a, 1937 - 1938; Jorgensen, 1948; Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Hustedt, 1937 - 1938, 1957; Jorgensen, 1948; Foged, 1948, 1953, 1968a; Manguin, 1952). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Hustedt, 1937 - 1938; Foged, 1948, 1953, 1968a; Patrick and Reimer, 1966). Beta - mesosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914). Current indifferent (Hustedt, 1937 - 1938; Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Spirit Lake (Krohn et al., 1974). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). North Twin Lake (Kutkukn, 1958). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Dutch Creek (Fee,

Table 141. Summary of distribution and relative abundance for Navicula cuspidata v. cuspidata

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		r		r	r		r				r
West Okoboji				r							
Center Lake											
Spirit Lake	r										
East Okoboji	r			r			r				

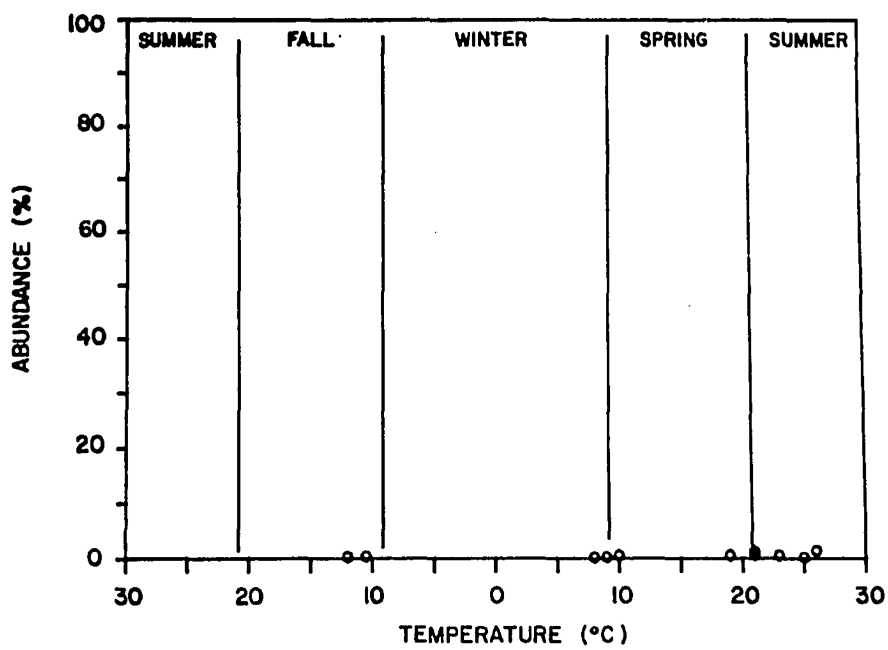

Figure 55. Abundance vs. temperature and season for populations of Navicula cuspidata

1967). Coralville Reservoir (Schmidt and Fee, 1967). Farm ponds (Ohl, 1965). Brewer's Creek (Edwards and Christensen, 1973). Soil (Loescher, 1971). Cayler Prairie (Reimer, 1970). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton of all lakes but Center Lake (Table 141). Observed during all seasons (Figure 55). Optimum temperature undefined, tolerance range 10° - 25° C, mesothermal.

Navicula decussis Ostr. var. *decussis*

Plate: 15, Fig. 18.

Critical reference: Patrick and Reimer, 1966, p. 518, Pl. 49, Fig. 15.

Descriptors: Striae, 14 - 16 in 10 µm. Length, 19 - 27 µm. Breadth, 7 - 8 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1954, 1968a; Hustedt, 1957). Oligohalobous indifferent (Foged, 1954, 1968a; Hustedt, 1957). Oligosaprobic (Hustedt, 1957). Rheophilous (Foged, 1954).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Clear Lake (Begres, 1971). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert,

Table 142. Summary of distribution and relative abundance for <u>Navicula decussis</u> v. <u>decussis</u>

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake			r	r	r						
West Okoboji					r			r			
Center Lake											
Spirit Lake								r			
East Okoboji				r				r	r		

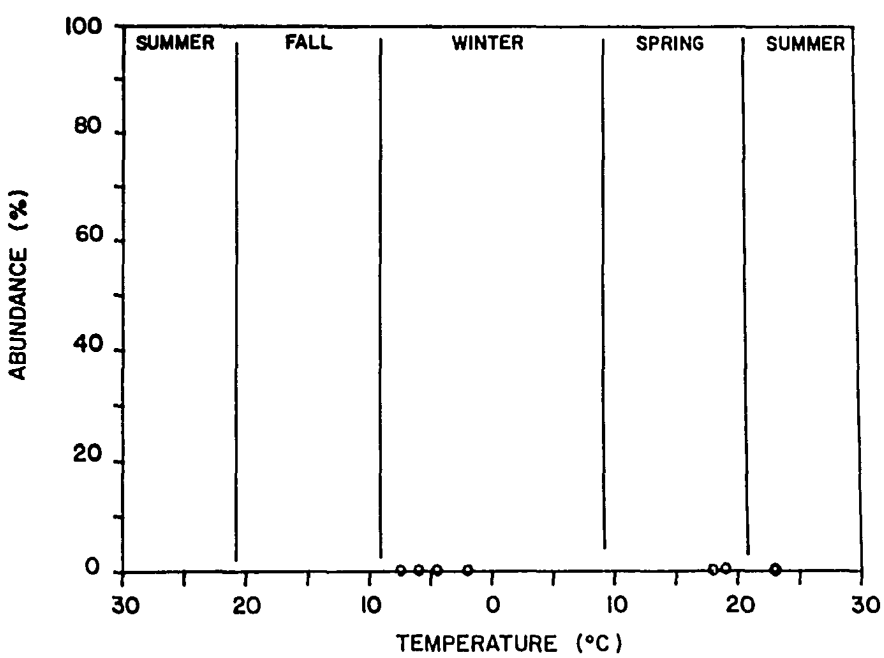

Figure 56. Abundance vs. temperature and season for populations of <u>Navicula decussis</u>

1977). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965).

Occurrence: Rare from the summer and winter plankton of the Lake District (Figure 56). Not encountered in samples from Center Lake (Table 142). Optimum temperature unknown, but occurs at temperature between 0°- 25°C.

Navicula elata Gandhi var. elata

Plate: 15, Fig. 17.

Critical reference: Gandhi, 1970, p. 774, Pl. 3, Fig. 73.

Descriptors: Striae, 15 in 10 µm. Length, 22 µm. Breadth, 7 µm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977).

Previous reports from Iowa: Clear Lake (Begres, 1971). Skunk River (Roeder, 1976)

Occurrence: Rare in a single spring sample from Silver Lake (Table 143). No clear indication of periodicity or temperature preference.

Navicula exigua var. capitata Patr.

Plate: 15, Fig. 6.

Critical reference: Patrick and Reimer, 1966, p. 522,

Table 143. Summary of distribution and relative abundance for *Navicula elata* v. *elata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r								
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Pl. 49, Fig. 24.

Descriptors: Striae, 15 in 10 µm. Length, 44 µm. Breadth, 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963). Appears to prefer water of less than 100 ppm hardness ($CaCO_3$)(Patrick and Reimer, 1966). Oligohalobous (Lowe, 1974).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Des Moines River (Starrett and Patrick, 1952; Gudmundson, 1969). Drainage ditches (Lowe, 1970).

Occurrence: Rare entity observed in a single summer plankton sample from Lake East Okoboji (Table 144). No clear indication of periodicity or optimum temperature range.

Navicula gottlandica Grun. var. *gottlandica*

Plate: 14, Fig. 4.

Critical reference: Patrick and Reimer, 1966, p. 509, Pl. 48, Fig. 14.

Descriptors: Striae, 12 - 13 in 10 µm. Length, 36 - 44 µm. Breadth, 8 - 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Brackish water (Patrick and Reimer, 1966).

Previous reports from Iowa: None.

Occurrence: Rare entity in the plankton of Lake West

Table 144. Summary of distribution and relative abundance for <u>Navicula</u> <u>exigua</u> v. <u>capitata</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				r							

Table 145. Summary of distribution and relative abundance for <u>Navicula</u> <u>gottlandica</u> v. <u>gottlandica</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji				r			r			r	
Center Lake											
Spirit Lake			r							r	
East Okoboji											

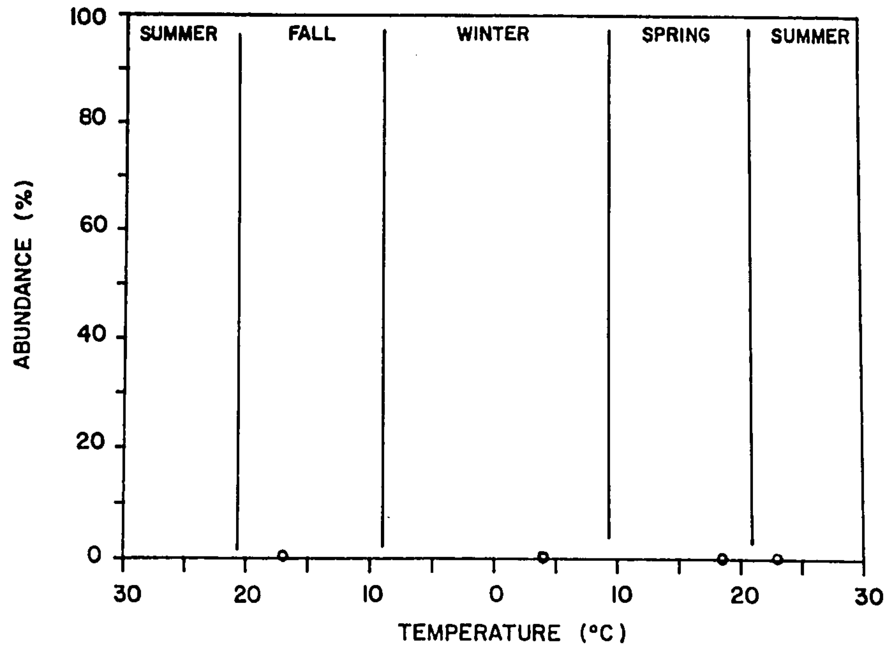

Figure 57. Abundance vs. temperature and season for populations of Navicula gottlandica

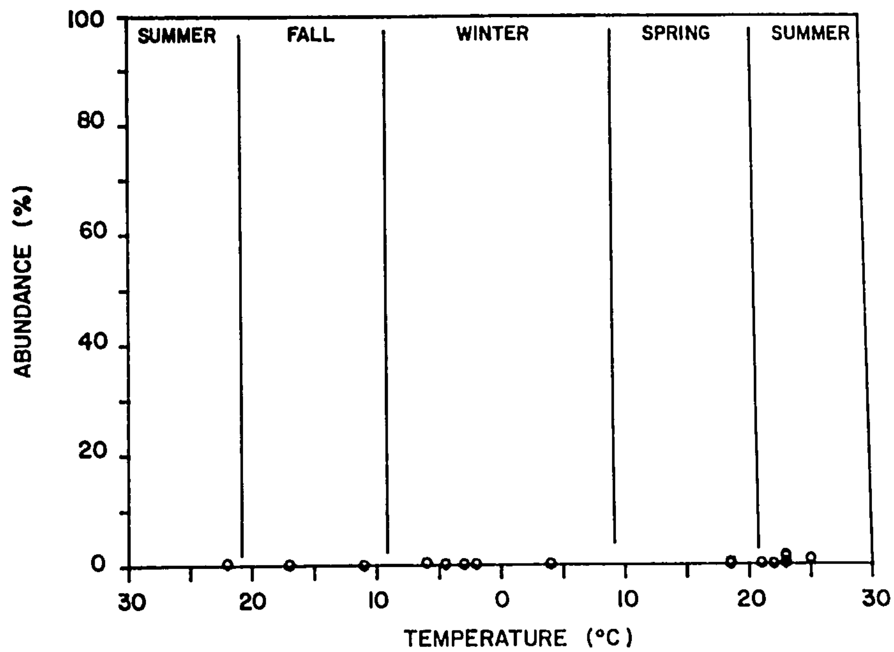

Figure 58. Abundance vs. temperature and season for populations of Navicula graciloides

Okoboji and Spirit Lake (Table 145). Collected during all seasons (Figure 57). The temperature tolerance range is 0°-25°C. No clear indication of temperature preference.

Navicula graciloides A. Mayer var. graciloides

Plate: 15, Fig. 19.

Critical reference: Patrick and Reimer, 1966, p. 516, Pl. 49, Figs. 9 - 10.

Descriptors: Striae, 11 - 14 in 10 µm. Length, 20 - 29 µm. Breadth, 6 - 7 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Slightly brackish water (Patrick and Reimer, 1966). pH indifferent (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Clear Lake (Begres, 1971). Subaerial habitats (Stoermer, 1962). Arend's Kettle Hole (Collins, 1968).

Occurrence: Encountered in the plankton of all lakes except Center Lake (Table 146). Rare, but present during all seasons (Figure 58). No clear indication of an optimum temperature for occurrence. Temperature tolerance range 0°-25°C.

Navicula laevissima Kutz. var. laevissima

Plate: 12, Fig. 30. Plate 17, Fig. 1.

Table 146. Summary of distribution and relative abundance for <u>Navicula</u> <u>graciloides</u> v. <u>graciloides</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r								
West Okoboji				r	r	r	r		r		
Center Lake											
Spirit Lake			r	r			r	r			
East Okoboji					r			r	r	r	

Table 147. Summary of distribution and relative abundance for <u>Navicula</u> <u>laevissima</u> Kutz. var. <u>laevissima</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

Critical reference: Patrick and Reimer, 1966, p. 497, Pl. 47, Fig. 13.

Descriptors: Striae, 13 in 10 µm. Length, 22.5 µm. Breadth, 7.2 µm.

Ecology: Freshwater; pH indifferent (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Collins, 1968). Spirit Lake (Krohn et al., 1974). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan lake beds (Hungerford, 1972).

Occurrence: Rare in a single spring sample from Spirit Lake (Table 147). No clear indication of periodicity or the optimum temperature range.

Navicula lanceolata (Ag.) Kutz. var. lanceolata

Critical reference: Patrick and Reimer, 1966, p. 511, Pl. 48, Figs. 19 - 20.

Descriptors: Striae, 12 - 13 in 10 µm. Length, 38 - 41.5 µm. Breadth, 9.5 - 10 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Hustedt, 1937 - 1938, 1957; Jorgensen, 1948; Foged, 1948, 1949, 1954, 1968a; Cholnoky, 1968). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Hustedt, 1937 - 1938, 1957;

Table 148. Summary of distribution and relative abundance for *Navicula lanceolata* v. *lanceolata*

Lake	Apr	May	Jun	Jul 1979	Aug	Sep	Oct	Nov	Jan	Mar 1980	Apr
Silver Lake					r	r	r	r	r	r	r
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji			r	r				r			

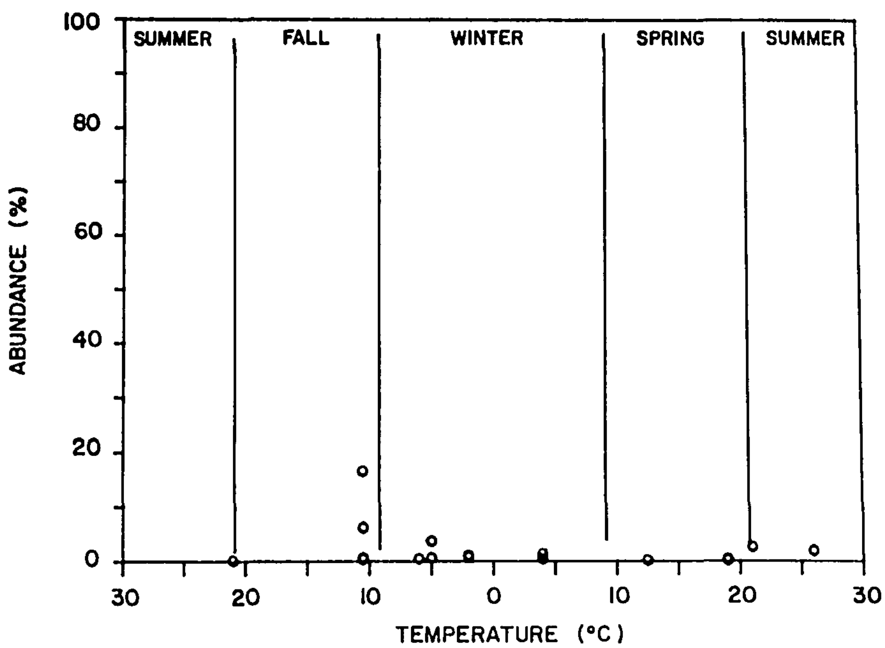

Figure 59. Abundance vs. temperature and season for populations of *Navicula lanceolata*

Foged, 1948, 1949, 1954, 1968a). Limnophilous (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Dutch Creek (Fee, 1967). Skunk River (Roeder, 1976). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Sewage stabilization ponds (Raschke, 1968).

Occurrence: Rare in the plankton of Silver Lake and Lake East Okoboji (Table 148). Perennial species, present during all seasons (Figure 63). No clear indication of periodicity or optimum temperature. Tolerance range 0° - 25° C.

Navicula latens Krasske var. *latens*

Plate: 15, Fig. 7.

Critical reference: Patrick and Reimer, 1966, p. 521, Pl.49, Fig. 21.

Descriptors: Striae, 11 in 10 µm. Length, 20 µm. Breadth, 8 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: None.

Occurrence: Rare in Lake West Okoboji (Table 149).

Table 149. Summary of distribution and relative abundance for *Navicula latens* v. *latens*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Navicula menisculus Schum. var. menisculus

Plate: 14, Fig. 12.

Critical reference: Hustedt, 1930a, p. 301, Fig. 517.

Descriptors: Striae, 9 - 14 in 10 µm. Length, 17 - 40 µm. Breadth, 7 - 12 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Coralville Reservoir (Schmidt and Fee, 1967). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965).

Occurrence: Rare in the plankton from Lake West Okoboji and Spirit Lake (Table 150). No clear indication of periodicity or temperature preference.

Navicula minima Grun. var. minima

Plate: 15, Fig. 8.

Critical reference: Patrick and Reimer, 1966, p. 488, Pl. 46, Figs. 17 - 18.

Descriptors: Striae, 26 in 10 µm. Length, 10 - 12 µm. Breadth, 5 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hustedt, 1937 - 1938; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977).

Table 150. Summary of distribution and relative abundance for *Navicula meniscusus* v. *meniscusus*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji									r		
Center Lake											
Spirit Lake			r					r	r		
East Okoboji											

Table 151. Summary of distribution and relative abundance for *Navicula minima* v. *minima*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1954, 1964; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Hustedt, 1957). Oligosaprobic (Hustedt, 1957). Current indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Farm ponds (Ohl, 1965). Drainage ditches (Edwards, 1974). Dutch Creek (Fee, 1967). Soil (Hayek and Hulbary, 1956).

Occurrence: Rare in a single summer plankton sample from Lake West Okoboji (Table 151). No clear indication of periodicity or temperature preference.

Navicula mucicoloides Hust. var. *musicoloides*

Critical reference: Hustedt, 1961 - 1966, p. 231, Fig. 1351.

Descriptors: Length, 10.5 µm. Breadth, 6 µm. Striae, 20 in 10 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: None.

Occurrence: Rare in the plankton of the Region (Table 152). Observed only in fall samples from Spirit Lake and Lake East Okoboji.

Table 152. Summary of distribution and relative abundance for *Navicula mucicoloides* v. *mucicoloides*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake							r				
East Okoboji						r					

Table 153. Summary of distribution and relative abundance for *Navicula nigirii* v. *nigirii*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake								o			
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				r							

<u>Navicula mutica</u> Kutz. var. <u>mutica</u>

<u>Plate</u>: 15, Fig. 9.

<u>Critical reference</u>: Patrick and Reimer, 1966, p. 454, Pl. 42, Fig. 2.

<u>Descriptors</u>: Valve lanceolate with rounded ends. Large central area with a distinct isolated punct. Striae, 17-18 in 10 µm. Length, 12 - 18 µm. Breadth, 5 - 5.4 µm.

<u>Ecology</u>: Freshwater, brackish, and alkaline waters (Patrick and Reimer, 1966). Periphytic (Schroeder, 1939; Manguin, 1952). pH indifferent (Foged, 1948, 1953, 1964) to alkaliphilous (Foged, 1949; Cholnoky, 1968). Oligohalobous (Foged, 1953, 1954) to halobion indifferent (Foged, 1953, 1954; Hustedt, 1957). Current indifferent (Foged, 1954). Fall maximum (Schroeder, 1939).

<u>Previous reports from Iowa</u>: Spirit Lake (Krohn et al., 1974). Clear Lake and Ventura Marsh (Begres, 1971). West Okoboji sediments, (Collins, 1968). Dutch Creek (Fee, 1967). Des Moines River (Gudmundson, 1969). Skunk River (Shobe, 1967). Farm ponds (Ohl, 1965). Cayler Prairie (Reimer, 1970). Soils (Hayek and Hulbary, 1956). Moss (Dodd and Stoermer, 1962).

<u>Occurrence</u>: This entity was collected in a single fall plankton sample from Silver Lake. Rare in the plankton of the Lake District.

Navicula nigirii De Notaris var. nigirii

Plate: 15, Fig. 9.

Critical reference: Granetti, 1968, p. 428, Figs. 1 - 2.

Descriptors: Striae fine, 5 in 10 µm. Length, 12.6 µm. Breadth, 4 µm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977).

Previous reports from Iowa: Clear Lake (Begres, 1971). Skunk River (Roeder, 1976).

Occurrence: Rare in the plankton from Silver Lake and Lake East Okoboji (Table 153). No clear indication of periodicity or temperature preference.

Navicula pelliculosa (Breb. ex Kutz.) Hilse var. pelliculosa

Plate: 15, Fig. 11.

Critical reference: Patrick and Reimer, 1966, p. 484, Pl. 46, Fig. 5.

Descriptors: Striae very fine, not resolved with the light microscope. Length, 7.4 µm. Breadth, 3.4 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); marshes (Hustedt, 1930a); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Alkaliphilous (Hustedt, 1937 - 1938, 1957; Cholnoky, 1968). Oligohalobous indifferent (Kolbe, 1927; Hustedt, 1937 - 1938, 1957).

Table 154. Summary of distribution and relative abundance for Navicula pelliculosa (Breb. ex Kutz.) Hilse var. pelliculosa

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake					r						
Spirit Lake											
East Okoboji											

Table 155. Summary of distribution and relative abundance for Navicula placentula v. placentula

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r								
West Okoboji									r		
Center Lake											
Spirit Lake											
East Okoboji											

Oligosaprobic (Hustedt, 1937 - 1938, 1957).

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964). Dutch Creek (Fee, 1967). Skunk River (Roeder, 1976). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Epizoic (Fee and Drum, 1965).

Occurrence: Rare in the plankton of the Lake District (Table 154). Observed in one summer sample from Center Lake. No clear indication of periodicity or temperature preference.

Navicula placentula (Ehr.) Kutz. var. *placentula*

Plate: 15, Fig. 20.

Critical reference: Patrick and Reimer, 1966, p. 523, Pl. 50, Fig. 1.

Descriptors: Striae, 8 - 9 in 10 μm. Length, 23 - 28 μm. Breadth, 11 - 13 μm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Patrick and Reimer, 1966). Saproxenous (Patrick and Reimer, 1966). Sometimes found in warm water (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Clear Lake (Begres, 1971). Skunk River (Roeder, 1976).

Occurrence: Rare in plankton samples from Silver Lake and Lake West Okoboji (Table 155). No clear indication of periodicity or temperature preference.

Navicula placentula f. rostrata Mayer

Plate: 16, Fig. 1.

Critical reference: Mayer, 1918, p. 125, Pl. 3, Fig. 27.

Descriptors: Length, 37 µm. Breadth, 13.5 µm. Striae, 9 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963).

Previous reports from Iowa: Clear Lake (Begres, 1971).

Occurrence: Rare in a single winter plankton sample from Spirit Lake (Table 156). No clear indication of periodicity or temperature preference.

Navicula platycephala O. Muller var. platycephala

Plate: 13, Fig. 12.

Critical reference: Muller, 1911, p. 84, Pl. 1, Fig. 12.

Descriptors: Length, 27 µm. Breadth, 7 µm. Striae, 19 in 10 µm.

Occurrence: Rare.

Navicula pseudoreinhardtii Patr. var. pseudoreinhardtii

Plate: 15, Fig. 15.

Table 156. Summary of distribution and relative abundance for <u>Navicula</u> <u>placentula</u> v. <u>rostrata</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake								r			
East Okoboji											

Table 157. Summary of distribution and relative abundance for <u>Navicula</u> <u>platycephala</u> O. Muller var. <u>platycephala</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake					r						
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Critical reference: Patrick and Reimer, 1966, p. 516, Pl. 49, Fig. 11.

Descriptors: Length, 15 µm. Breadth, 6 µm. Striae, 15 in 10 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977). Insufficiently known.

Previous reports from Iowa: Spirit Lake (Krohn et al. 1974).

Occurrence: Most frequently collected in Silver Lake but always rare (Table 158).

Navicula pupula Kutz. var. *pupula*

Plate: 15, Fig. 12.

Critical reference: Patrick and Reimer, 1966, p. 495, Pl. 47, Fig. 7.

Descriptors: Striae, 22 - 26 in 10 µm. Length, 14 - 24 µm. Breadth, 6 - 9 µm.

Ecology: Freshwater lakes (Jorgensen, 1948, Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). pH indifferent (Foged, 1948, 1953, 1958, 1968a; Hustedt, 1957; Merilainen, 1967). Eutrophic (Jorgensen, 1948). Oligohalous indifferent (Hustedt, 1937 - 1938, 1957; Jorgensen, 1948; Foged, 1948, 1949, 1953). Current indifferent (Foged, 1948, 1954).

Table 158. Summary of distribution and relative abundance for *Navicula pseudoreinhardtii* v. *pseudoreinhardtii*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r	r			r	r	r	r	
West Okoboji											
Center Lake				r							
Spirit Lake											
East Okoboji				r							

Table 159. Summary of distribution and relative abundance for *Navicula pupula* v. *pupula*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake				r	r						
West Okoboji				r	r	r			r		
Center Lake											
Spirit Lake											
East Okoboji											

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Coralville Reservoir (Schmidt and Fee, 1967). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Dutch Creek (Fee, 1967). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrrence: Rare in the summer and fall plankton of Silver Lake and Lake West Okoboji (Table 159). No clear indication of periodicity or temperature preference (Figure 60).

Navicula pupula var. *capitata* Skv. and Meyer

Plate: 15, Fig. 13.

Critical reference: Patrick and Reimer, 1966, p. 496, Pl. 47, Fig. 8.

Descriptors: Striae, 22 in 10 um. Length, 19 µm. Breadth, 5.5 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). pH indifferent (Jorgensen, 1927; Foged,

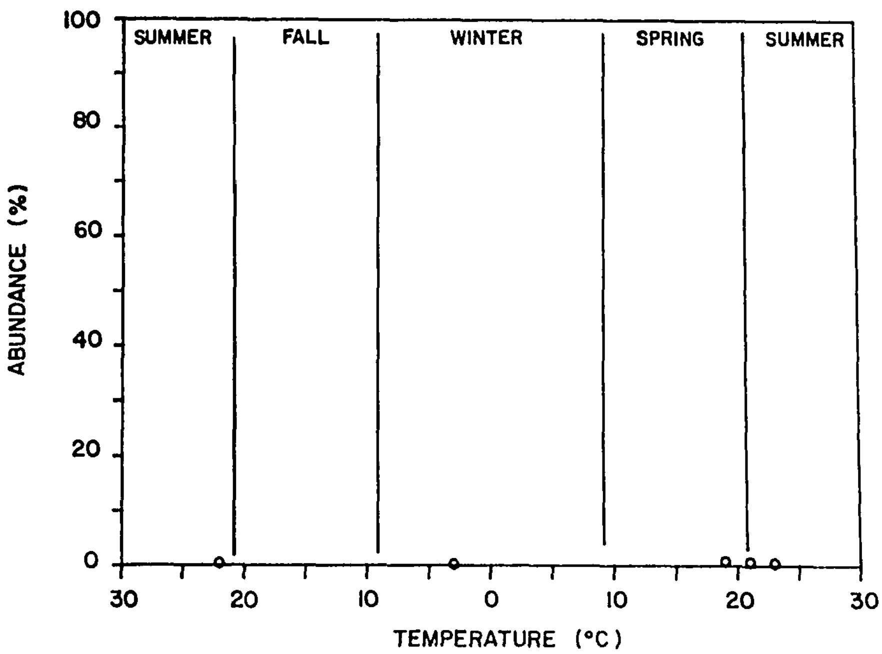

Figure 60. Abundance vs. temperature and season for populations of Navicula pupula

1948, 1953, 1954, 1958, 1968a; Hustedt, 1957; Patrick and Reimer, 1966). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1953, 1954, 1968a). Current indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965). Silver Lake Fen (Shobe et al., 1963).

Occurrence: Rare in the plankton of the Lake District (Table 160). Observed in a summer plankton sample from Lake West Okoboji. No clear pattern of periodicity or optimum temperature for growth.

Navicula pupula var. elliptica Hust.

Plate: 15, Fig. 14.

Critical reference: Patrick and Reimer, 1966, p. 496, Pl. 47, Fig. 11.

Descriptors: Striae, 25 - 30 in 10 µm. Length, 14 - 15 µm. Breadth, 6.3 µm

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Similar to the nominate variety (Patrick and Reimer, 1966).

Table 160. Summary of distribution and relative abundance for <u>Navicula</u> <u>pupula</u> v. <u>capitata</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake											
East Okoboji											

Table 161. Summary of distribution and relative abundance for <u>Navicula</u> <u>pupula</u> v. <u>elliptica</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake							r				
East Okoboji											

Previous reports from Iowa: None.

Occurrence: Rare in plankton samples from Lake West Okoboji and Spirit Lake (Table 161). No clear indication of periodicity or temperature preference.

Navicula pygmaea Kutz. var. pygmaea

Plate: 14, Fig. 8.

Critical reference: Patrick and Reimer, 1966, p. 442, Pl. 39, Fig. 4.

escriptors: Striae, 22 in 10 µm. Length, 17 - 25 µm. Breadth, 8 - 12 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Alkalibiontic (Hustedt, 1957; Foged, 1964) to alkaliphilous (Foged, 1953). Mesohalobous (Kolbe, 1927; Hustedt, 1930a, 1937 - 1938; Foged, 1949, 1953, 1954; Cholnoky, 1968). Mesosaprobic (Kolbe, 1927; Budde, 1931; Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Coralville Reservoir (Schmidt and Fee, 1967). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974).

Occurrence: Rare form observed only in plankton samples from Lake West Okoboji and Spirit Lake (Table 162). No clear indication of periodicity or temperature preference.

Navicula radiosa Kutz. var. radiosa

Plate: 14, Fig. 6.

Critical reference: Patrick and Reimer, 1966, p. 509, Pl. 48, Fig. 15.

Descriptors: Striae, 11 - 12 in 10 μm. Length, 38 - 45 μm. Breadth, 7 - 10 μm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938; Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). pH indifferent (Hustedt, 1937 - 1938, 1957; Jorgensen, 1948; Foged, 1948, 1954, 1968a; Cholnoky, 1968). Oligohalobous indifferent (Hustedt, 1937 - 1938; Foged, 1948, 1949, 1954, 1968a; Patrick and Reimer, 1966). Oligosaprobic (Hustedt, 1957) to beta - mesosaprobic (Kolkwitz and Marsson, 1908). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Eurythermal and oligothermal to mesothermal (Scheele, 1952).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). East Lake Okoboji (Volker, 1963). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Arend's Kettle

Table 162. Summary of distribution and relative abundance for <u>Navicula</u> <u>pygmaea</u> v. <u>pygmaea</u>

Lake				1979						1980	
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake							r				
East Okoboji											

Table 163. Summary of distribution and relative abundance for <u>Navicula</u> <u>radiosa</u> v. <u>radiosa</u>

Lake				1979						1980	
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				o							
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Hole (Collins, 1968). Pillsbury and Sylvan Lake beds (Hungerford, 1972). Skunk River (Roeder, 1976).

Occurrence: Rare in the plankton of the Lake District (Table 163). Collected from Silver Lake and Lake West Okoboji. No clear indication of periodicity or temperature preference.

Navicula radiosa var. *parva* Wallace

Plate: 15, Fig. 21.

Critical reference: Patrick and Reimer, 1966, p. 510, Pl. 48, Fig. 16.

Descriptors: Striae, 14 in 10 µm. Length, 33 - 38 µm. Breadth, 6.3 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Seems to prefer water of low mineral content (Patrick and Reimer, 1966).

Previous reports from Iowa: None.

Occurrence: Rare in the winter plankton of Silver Lake and Lake East Okoboji (Table 164). No clear indication of periodicity or optimum temperature for growth.

Navicula radiosa var. *tenella* (Breb. ex Kutz.) Grun.

Plate: 15, Fig. 22.

Critical reference: Patrick and Reimer, 1966, p. 510,

Table 164. Summary of distribution and relative abundance for *Navicula radiosa* v. *parva*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake								r			
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji								r			

Table 165. Summary of distribution and relative abundance for *Navicula radiosa* v. *tenella*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r	r						
West Okoboji											
Center Lake											
Spirit Lake							r				
East Okoboji											

Pl. 48, Fig. 17.

Descriptors: Striae, 14 - 15 in 10 µm. Length, 29 - 31.5 µm. Breadth, 5.4 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Manguin, 1952; Hornung, 1959). pH indifferent (Foged, 1954) to alkaliphilous (Foged, 1953). Oligohalobous indifferent (Foged, 1953, 1954; Patrick and Reimer, 1966). Current indifferent (Foged, 1954).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Clear Lake (Begres, 1971). Des Moines River (Drum, 1964). Dutch Creek (Fee, 1967). Skunk River (Roeder, 1976). Farm ponds (Ohl, 1965). Silver Lake Fen (Shobe et al., 1963).

Occurrence: Rare in the summer and fall plankton of Silver Lake and Spirit Lake (Table 165). No clear indication of temperature range or periodicity.

Navicula reinhardtii (Grun.) Grun. var. *reinhardtii*

Plate: 15, Fig. 23.

Critical reference: Patrick and Reimer, 1966, p. 517, Pl. 49, Fig. 12.

Descriptors: Striae, 8 - 9 in 10 µm. Length, 38 - 50 µm. Breadth, 15 - 17 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Alkalbiontic (Jorgensen, 1948; Foged, 1948, 1949, 1954, 1968a; Hustedt, 1957) to alkaliphilous (Foged, 1958, 1964; Cholnoky, 1968). Eutrophic (Jorgensen, 1948). Saproxenous (Hustredt, 1957) to beta-mesosaprobic (Fjerdingstadt, 1950).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). East Lake Okoboji (Volker, 1963). Des Moines River (Drum, 1964). Spirit Lake (Krohn et al., 1974).

Occurrence: Rare in the plankton of Spirit Lake and Lake East Okoboji (Table 166). No clear indication of the temperature tolerance range or periodicity.

Navicula salinarum var. intermedia (Grun.) Cleve

Plate: 15, Fig. 25.

Critical reference: Patrick and Reimer, 1966, p. 503, Pl. 48, fig. 2.

Descriptors: Striae, 13 - 15 in 10 µm. Length, 31 - 37 µm. Breadth, 7 - 8 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977). Water of high mineral content to brackish water

Plankton diatom assemblages of the

Iowa Lakes Region

by

Greeneville Berkeley Hall

Volume 2 of 2

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Department: Botany
Major: Botany (Aquatic Plant Biology)

Approved:

John D. Dodd
In Charge of Major Work

Ronald C. Coolbaugh
For the Major Department

For the Graduate College

Iowa State University
Ames, Iowa

1986

TABLE OF CONTENTS

Table 166. Summary of distribution and relative abundance for *Navicula reinhardtii* v. *reinhardtii*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake							r				
East Okoboji			r						r		

Table 167. Summary of distribution and relative abundance for *Navicula salinarum* v. *intermedia*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			c	r	r			r			
West Okoboji			r	r		r	r				
Center Lake											
Spirit Lake			r								
East Okoboji		r	r	o		r	r				

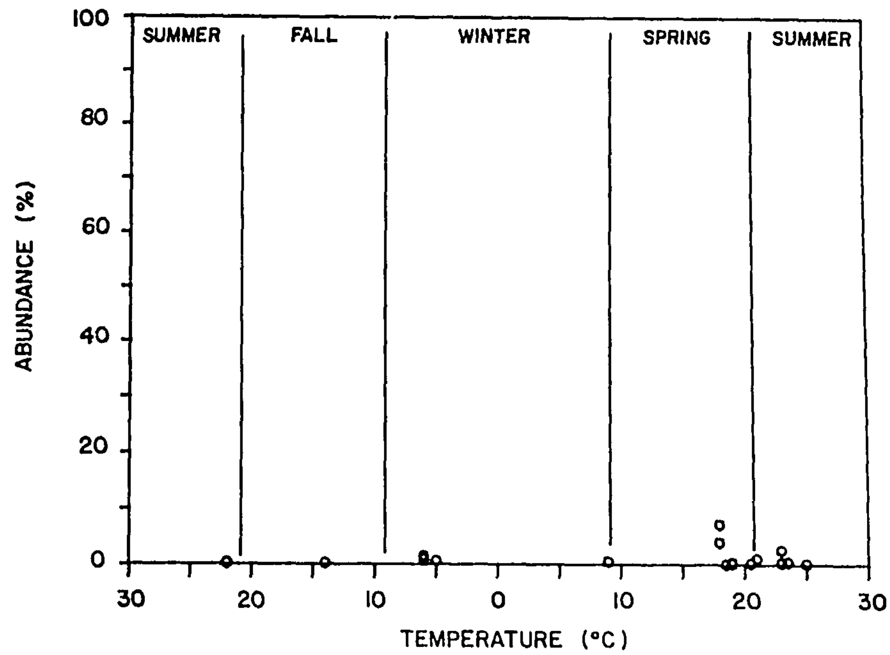

Figure 61. Abundance vs. temperature and season for populations of *Navicula salinarum* v. *intermedia*

(Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Collins, 1968). Spirit Lake (Krohn et al., 1974). Drainage ditches (Lowe, 1970; Edwards, 1974). Des Moines River (Gudmundson, 1969). Skunk River (Roeder, 1976).

Occurrence: Perennial species observed during all seasons (Figure 61), but always rare (Table 167). Greatest frequency of occurrence during the late spring and summer. No clear indication of periodicity or temperature preference.

Navicula scutelloides Wm. Amith ex Greg. var. *scutelloides*

Plate: 15, Fig. 24.

Critical reference: Patrick and Reimer, 1966, p. 450, Pl. 41, Fig. 3.

Descriptors: Striae, 8 - 10 in 10 µm. Length, 27 - 30 µm. Breadth 15 µm.

Ecology: Freshwater lakes (Hustedt, 1930a, 1937 - 1938, 1957; Jorgensen, 1948; Raabe, 1951; Cholnoky, 1968). Alkalibiontic (Foged, 1948, 1954, 1968a; Hustedt, 1957). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Hustedt, 1957). Saproxenous (Hustedt, 1957). Limnobiontic (Foged, 1948, 1954; Hustedt, 1949).

Table 168. Summary of distribution and relative abundance for *Navicula scutelloides* v. *scutelloides*

Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
	1979								1980		
Silver Lake											
West Okoboji			r	r	r		r	r	r	r	r
Center Lake											
Spirit Lake			r	r					r		
East Okoboji				r							

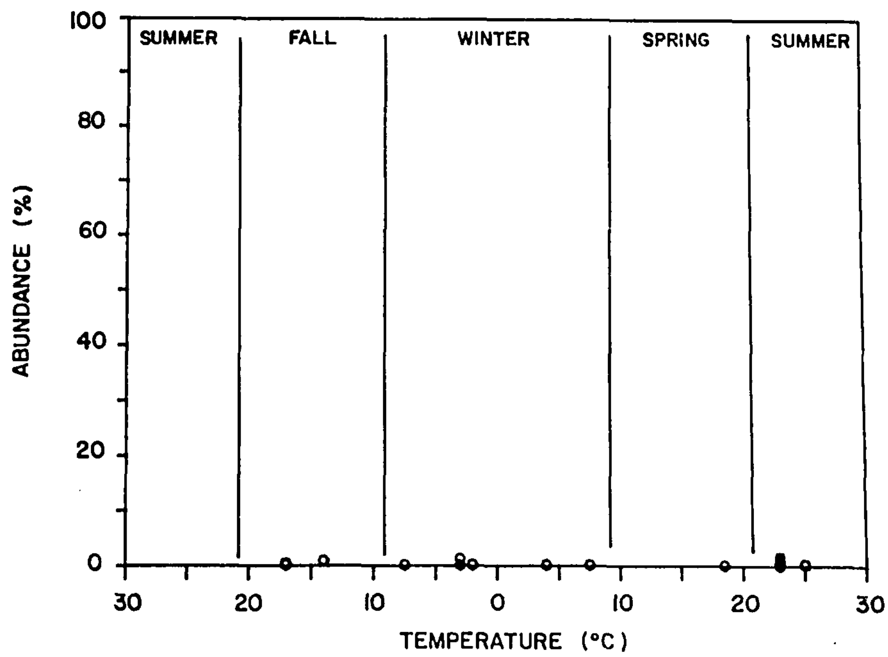

Figure 62. Abundance vs. temperature and season for populations of *Navicula scutelloides*

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hostetter and Stoermer, 1968, Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964). Pillsbury and Sylvan lake beds (Hungerford, 1972).

Occurrence: Frequently observed in plankton samples from Lake West Okoboji and Spirit Lake (Table 168). No clear indication of periodicity or optimum temperature range (Figure 62).

Navicula simplex Krasske var. *simplex*

Plate: 16, Fig. 5.

Critical reference: Hustedt, 1930a, p. 296, Fig. 500.

Descriptors: Striae, 17 in 10 µm. Length, 30 µm. Breadth, 6.3 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971).

Occurrence: Rare in a single spring sample from Lake East Okoboji (Table 169). No clear indication of periodicty or temperature preference.

Table 169. Summary of distribution and relative abundance for <u>Navicula</u> <u>simplex</u> v. <u>simplex</u>

	1979									1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											r
East Okoboji											

<u>Navicula stroesei</u> (Ostr.) A. Cleve var. <u>stroesei</u>

<u>Critical reference</u>: Cleve-Euler, 1953, p. 122, Fig. 743a-e.

<u>Descriptors</u>: Striae, 17 in 10 µm. Length, 20 µm. Breadth, 6 µm.

<u>Ecology</u>: Insufficiently known.

<u>Previous reports from Iowa</u>: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a, b; 1964; Collins, 1968; Hosseini, 1979). Arend's Kettle Hole (Collins, 1968).

<u>Occurrence</u>: Rare in a single summer plankton sample from Lake West Okoboji (Table 170). No clear indication of periodicity or temperature preference.

<u>Navicula subrotundata</u> Hust. var. <u>subrotundata</u>

<u>Plate</u>: 13, Fig. 13.

<u>Critical reference</u>: Hustedt, 1961 - 1962, p. 272, Fig. 1402 a - m.

<u>Descriptors</u>: Striae, 26 in 10 um. Length, 12 um. Breadth, 5.2 µm.

<u>Ecology</u>: Freshwater rivers (Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

<u>Previous reports from Iowa</u>: Clear Lake (Begres, 1971).

<u>Occurrence</u>: Rare in the plankton of the Lake District

Table 170. Summary of distribution and relative abundance for <u>Navicula stroesei</u> v. <u>stroesei</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Table 171. Summary of distribution and relative abundance for *Navicula subrotundata* v. *subrotundata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				r							

(Table 171). Observed in a summer sample from Lake East Okoboji. No clear indication of periodicity or optimum temperature range.

Navicula tantula Hust. var. tantula

Plate: 13, Fig. 14.

Critical reference: Hustedt, 1961 - 1962, p. 250, Fig. 1375 a - d.

Descriptors: Striae, 30 in 10 µm. Length, 9 µm. Breadth, 3.6 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Coralville Reservoir (Schmidt and Fee, 1967). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Soil (Loescher, 1971). Cayler Prairie (Reimer, 1970). Skunk River (Roeder, 1976).

Occurrence: Rare in a single summer plankton sample from Lake East Okoboji (Table 172). No clear indication of periodicity or temperature preference.

Navicula tripunctata (O.F. Mull.) Bory var. tripunctata

Plate: 14, Fig. 2.

Critical reference: Patrick and Reimer, 1966, p. 513,

Table 172. Summary of distribution and relative abundance for Navicula tantula Hust. var. tantula

			1979						1980		
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				r							

Table 173. Summary of distribution and relative abundance for Navicula tripunctata v. tripunctata

			1979						1980		
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake	r			r		r	r	r	r		
West Okoboji				r						r	
Center Lake											
Spirit Lake			r								
East Okoboji			r					r			

Pl. 49, Fig. 2.

Descriptors: Striae, 10 - 12 in 10 μm. Length, 34 - 58.5. Breadth, 6 - 9 μm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977); lakes and ponds (Jorgensen, 1948; Stoermer and Yang, 1969). Periphytic (Hustedt, 1930a; Jorgensen, 1948; Hornung, 1959); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Jorgensen, 1948; Foged, 1948, 1949, 1954, 1958, 1968a; Hustedt, 1957; Cholnoky, 1968). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1949, 1954, 1968a; Hustedt, 1957) to euryhalobous (Kolbe, 1927; Foged, 1948; Hornung, 1959). Oligosaprobic (Hustedt, 1957). Rheophilous (Foged, 1948, 1954; Hornung, 1959). Eurythermal and oligothermal to mesothermal (Scheele, 1952).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Brewer's Creek (Edwards and Christensen, 1973). Farm ponds (Ohl, 1965). Epizoic (Fee and Drum, 1965).

Occurrence: Rare in the plankton of the Lake District (Table 173). Observed in samples from all the lakes except Center Lake. Possibly an oligothermal form (Figure 63).

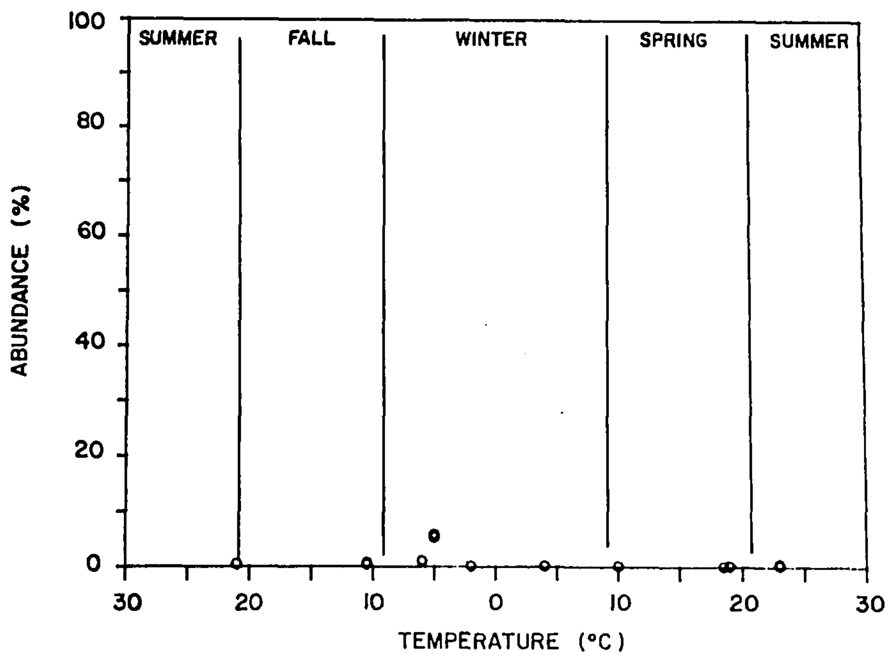

Figure 63. Abundance vs. temperature and season for populations of *Navicula tripunctata*

Temperature tolerance range 0°- 10°C.

Navicula tripunctata var. schizonemoides (V.H.) Patrick

Plate: 16, Fig. 2.

Critical reference: Patrick and Reimer, 1966, p. 514, Pl. 49, Fig. 4.

Descriptors: Striae, 12 in 10 µm. Length, 28 µm. Breadth, 7 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969). Oligohalobous (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Farm ponds (Ohl, 1965).

Occurrence: Less frequently encountered than the nominate variety (Table 174). Observed in a single summer plankton sample from Silver Lake. No clear indication of periodicity or temperature preference.

Navicula tuscula Ehr. var. tuscula

Plate: 16, Fig. 3.

Critical reference: Patrick and Reimer, 1966, p. 539, Pl. 52, Fig. 7.

Descriptors: Striae, 11 - 12 in 10 µm. Length, 31.5 - 38 µm. Breadth, 11 - 14.5 µm.

Table 174. Summary of distribution and relative abundance for Navicula tripunctata v. schizonemoides

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r							
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 175. Summary of distribution and relative abundance for Navicula tuscula v. tuscula

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake										r	
West Okoboji									r		
Center Lake											
Spirit Lake			r	r			r	r			
East Okoboji											

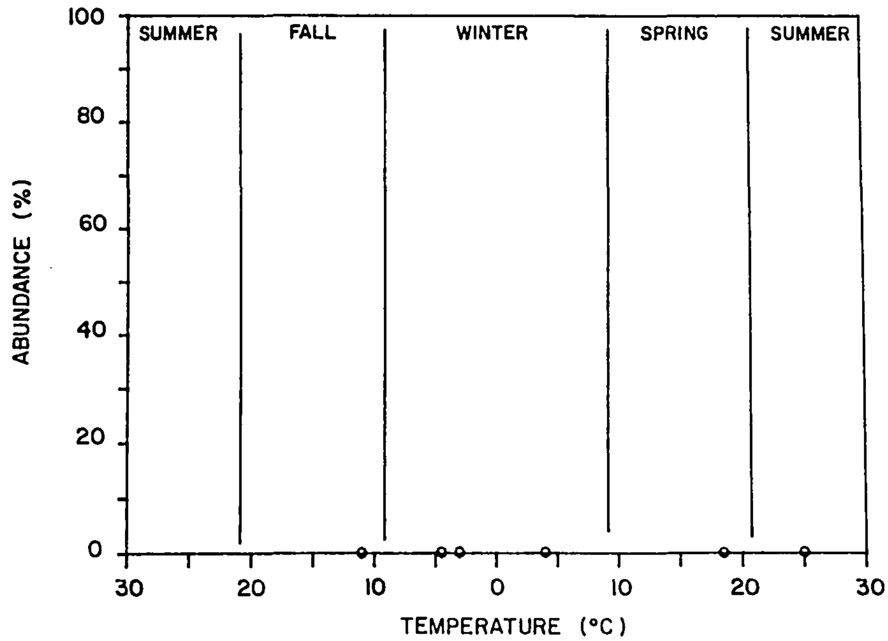

Figure 64. Abundance vs. temperature and season for populations of *Navicula tuscula*

Ecology: Freshwater rivers (Collins and Kalinsky, 1977); Lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton of Spirit Lake, Lake West Okoboji and Silver Lake (Table 175) Perennial form.

Navicula tuscula f. minor Hust.

Plate: 14, Fig. 9.

Critical reference: Hustedt, 1930a, p. 308, Fig. 553.

Descriptors: Striae, 12 in 10 µm. Length, 14 - 17 µm. Breadth, 7.6 - 8.5 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: Clear Lake (Begres, 1971).

Occurrence: Rare in the plankton of Lake West Okoboji and Spirit lake (Table 176). No clear indication of periodicity or optimum temperature for occurrence.

Navicula tuscula f. rostrata Hust.

Plate: 16, Fig. 4.

Table 176. Summary of distribution and relative abundance for <u>Navicula</u> <u>tuscula</u> v. <u>minor</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake							r				r
East Okoboji											

Table 177. Summary of distribution and relative abundance for <u>Navicula</u> <u>tuscula</u> v. <u>rostrata</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake					r						
East Okoboji											

Critical reference: Hustedt, 1930a, p. 308.

Descriptors: Striae, 12 in 10 µm. Length, 38 µm. Breadth, 13.5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: None.

Occurrence: Rare in a single summer sample from Spirit Lake (Table 177). No clear indication of periodicity or temperature preference.

Navicula viridula var. *argunensis* Skv.

Plate: 16, Fig. 6.

Critical reference: Skvortzow, 1938, p. 408, Pl. 1, Fig. 9 and 33.

Descriptors: Striae, 12 in 10 µm. Length, 30.4 µm. Breadth, 6 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Soil (Loescher, 1971). Skunk River (Roeder, 1976).

Occurrence: Rare in the spring plankton of Silver Lake (Table 178). No clear indication of periodicity or

Table 178. Summary of distribution and relative abundance for *Navicula viridula* v. *argunensis*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r								
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 179. Summary of distribution and relative abundance for *Navicula* sp. 1

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake							r				
East Okoboji	r	r									

optimum temperature range.

<u>*Navicula* sp. 1</u>

<u>Plate</u>: 16, Fig. 7.

<u>Descriptors</u>: Length, 23.5 µm. Breadth, 8 µm. striae, 18 in 10 µm.

<u>Occurrence</u>: Rare in the plankton of Spirit Lake and Lake East Okoboji (Table 179).

<u>*Navicula* sp. 2</u>

<u>Plate</u>: 16, Fig. 8.

<u>Descriptors</u>: Length, 34 µm. Breadth, 9 µm. striae, 13 in 10 µm.

<u>Occurrence</u>: Rare in the plankton of the lake District (Table 180). Observed only in collections from Silver Lake, Center Lake, and Lake East Okoboji.

<u>*Navicula* sp. 3</u>

<u>Plate</u>: 16, Fig. 17.

<u>Descriptors</u>: Length, 19 µm. Breadth, 6 µm. striae, 12 in 10 µm.

<u>Occurrence</u>: Rare in the plankton of lakes East and West Okoboji (Table 181).

<u>*Navicula* sp. 4</u>

<u>Plate</u>: 16, Fig. 20.

<u>Descriptors</u>: Length, 10 µm. Breadth, 4.5 µm.

Table 180. Summary of distribution and relative abundance for <u>Navicula</u> sp. 2

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r								
West Okoboji											
Center Lake					r						
Spirit Lake											
East Okoboji	r		r								

Table 181. Summary of distribution and relative abundance for <u>Navicula</u> sp. 3

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji			r								

Table 182. Summary of distribution and relative abundance for *Navicula* sp. 4

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji						r					
Center Lake											
Spirit Lake											
East Okoboji				r							

Table 183. Summary of distribution and relative abundance for *Navicula* sp. 5

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji				r							

Striae, 15 in 10 µm.

Occurrence: Rare in the plankton of lakes East and West Okoboji (Table 182).

Navicula sp. 5

Plate: 16, Fig. 9.

Descriptors: Length, 23 µm. Breadth, 7 µm. Striae, 13 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 183).

Navicula sp. 6

Plate: 16, Fig. 10.

Descriptors: Length, 30 µm. Breadth, 6 µm. Striae, 12 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 184).

Navicula sp. 7

Plate: 16, Fig. 11.

Descriptors: Length, 27 µm. Breadth, 6 µm. Striae, 14 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 185).

Navicula sp. 8

Plate: 16, Fig. 12.

Table 184. Summary of distribution and relative abundance for <u>Navicula</u> sp. 6

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji						r					

Table 185. Summary of distribution and relative abundance for <u>Navicula</u> sp. 7

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji							r				

Table 186. Summary of distribution and relative abundance for _Navicula_ sp. 8

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											r

Table 187. Summary of distribution and relative abundance for _Navicula_ sp. 9

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r									
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Descriptors: Length, 18 µm. Breadth, 8 µm. Striae, 11 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 186).

Navicula sp. 9

Plate: 16, Fig. 13.

Descriptors: Length, 23 µm. Breadth, 6 µm. Striae, 12 in 10 µm.

Occurrence: Rare in a single plankton sample from Silver Lake (Table 187).

Navicula sp. 10

Plate: 16, Fig. 18.

Descriptors: Length, 15.5-16 µm. Breadth, 4-4.5 µm. Striae, 17 in 10 µm.

Occurrence: Rare in plankton samples from Silver Lake and Spirit Lake (Table 188).

Navicula sp. 11

Plate: 16, Fig. 15.

Descriptors: Length, 23 µm. Breadth, 5 µm. Striae, 14 in 10 µm.

Occurrence: Rare in a single plankton sample from Silver Lake (Table 189).

Table 188. Summary of distribution and relative abundance for *Navicula* sp. 10

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake					r	r					
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

Table 189. Summary of distribution and relative abundance for *Navicula* sp. 11

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake								r			
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Navicula sp. 12

Plate: 16, Fig. 19.

Descriptors: Length, 8 µm. Breadth, 4 µm. Striae, 14 in 10 µm.

Occurrence: Rare. Observed only in plankton collections from Lake West Okoboji (Table 190).

Navicula sp. 13

Plate: 14, Fig. 7.

Descriptors: Length, 54 µm. Breadth, 9.5 µm. Striae, 11 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake West Okoboji (Table 191).

Navicula sp. 14

Plate: 16, Fig. 14.

Descriptors: Length, 45 µm. Breadth, 11 µm. Striae, 9 in 10 µm.

Occurrence: Rare in plankton samples only from Spirit Lake (Table 192).

Table 190. Summary of distribution and relative abundance for *Navicula* sp. 12

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake											
West Okoboji				o	r						
Center Lake											
Spirit Lake											
East Okoboji											

Table 191. Summary of distribution and relative abundance for *Navicula* sp. 13

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake											
West Okoboji				r							
Center Lake											
Spirit Lake											
East Okoboji											

Table 192. Summary of distribution and relative abundance for <u>Navicula</u> sp. 14

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake				r				r			
East Okoboji											

Table 193. Summary of distribution and relative abundance for <u>Navicula</u> sp. 15

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake									r		
East Okoboji											

Navicula sp. 15

Plate: 16, Fig. 16.

Descriptors: Length, 30.5 µm. Breadth, 9 µm. Striae, 12 in 10 µm.

Occurrence: Rare in a single plankton sample from Spirit Lake (Table 193).

Neidium iridis (Ehr.) Cl. var. iridis

Plate: 13, Fig. 6.

Critical reference: Patrick and Reimer, 1966 p. 386, Pl. 34, Fig. 1.

Descriptors: Length, 47 µm. Breadth, 14 µm. Striae, 18 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). pH indifferent (Hustedt, 1937 - 1938, 1957; Foged, 1948; Patrick and Reimer, 1966). Halophobous (Kolbe, 1927; Foged, 1948, 1954; Patrick and Reimer, 1966); halobion indifferent (Foged, 1948, 1964; Hustedt, 1957). Oligosaprobic (Hustedt, Limnobiontic (Foged, 1948, 1954; Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake and Ventura Marsh (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Gudmundson, 1969).

Occurrence: Rare in the plankton of Lakes East and

Table 194. Summary of distribution and relative abundance for *Neidium iridis* v. *iridis*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake		r									
East Okoboji					r						

Table 195. Summary of distribution and relative abundance for *Neidium iridis* v. *ampliatum*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake	r										
Spirit Lake											
East Okoboji											

West Okoboji and Spirit Lake (Table 194).

Neidium iridis var. ampliatum (Ehr.) Cleve

Plate: 13, Fig. 8.

Critical reference: Patrick and Reimer, 1966, p. 388, Pl. 34, Fig. 5.

Descriptors: Striae, 18 in 10 µm. Length, 52.2 µm. Breadth, 14 µm.

Ecology: Freshwater, streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). More commonly a lake or bog form, but occasionally found in streams (Patrick and Reimer, 1966). pH indifferent (Patrick and Reimer, 1966).

Previous reports from Iowa: Drainage ditches (Edwards, 1974).

Occurrence: Rare in the spring plankton of Center Lake (Table 195). No clear indication of periodicity or temperature preference.

Neidium sp. 1

Plate: 13, Figs. 3 and 5.

Descriptors: Length, 99 µm. Breadth, 21 µm. Striae, 11 in 10 µm.

Occurrence: Rare form (Table 196). Observed only in a single plankton sample from Silver Lake.

Nitzschia acicularis (Kutz.) Wm. Smith var. acicularis

Plate: 21, Fig. 9.

Table 196. Summary of distribution and relative abundance for <u>Neidium</u> sp. 1

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake					r						
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 197. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>acicularis</u> v. <u>acicularis</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake		r									
East Okoboji				r							

Critical reference: Hustedt, 1930a, p. 423, Fig. 821.

Descriptors: Striae very fine not readily observed with the light microscope. Length, 53-73 µm. Breadth, 2-3 µm. Keel punctae, 16-17 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Hustedt, 1930a, 1937 - 1938; Foged, 1948, 1954; Hornung, 1959). Oligohalobous indifferent (Foged, 1948, 1954; Hustedt, 1957). Beta - mesosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914). Limnophilos (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). North Twin Lake (Kutkukn, 1958). Des Moines River (Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Brewer's Creek (Edwards and Christensen, 1973). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Epizoic (Fee and Drum, 1965).

Occurrence: Rare in the plankton of the Lake District (Table 197). Observed in spring and summer plankton from Lake West Okoboji, Spirit Lake, and Lake East Okoboji. No clear indication of periodicity or optimum temperature for growth.

Nitzschia acuta Hantzsch var. acuta

Plate: 21, Fig. 8.

Critical reference: Hustedt, 1930a, p. 412, Fig. 790.

Descriptors: Striae very fine, not readily visible with the light microscope. Length, 111 µm. Breadth, 5 µm. Keel punctae, 7 in 10 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971).

Occurrence: Rare in spring plankton of Silver Lake and Lake East Okoboji (Table 198). No clear indication of periodicity or temperature preference.

Nitzschia amphibia Grun. var. amphibia

Plate: 21, Fig. 10 and 11.

Critical reference: Hustedt, 1930a, p. 414, Fig. 793.

Descriptors: Striae, 20 - 22 in 10 µm. Length, 8 - 31 µm. Breadth, 3 - 5 µm. Keel punctae, 10 in 10 µm.

Ecology: Freshwater lakes (Hustedt, 1937 - 1938; Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hustedt, 1937 - 1938; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938; Manguin, 1952; Scheele, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1953, 1958, 1964, 1968a) to

Table 198. Summary of distribution and relative abundance for *Nitzschia acuta* v. *acuta*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		r									
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji	r		r								

Table 199. Summary of distribution and relative abundance for *Nitzschia amphibia* v. *amphibia*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake		r	o	r	o	o	o	o		r	
West Okoboji				r	r	r	r	r		r	r
Center Lake				c	c	c	r			r	r
Spirit Lake			r	r	r	r	r		r	r	
East Okoboji	r	r	r	o	r	o	r	o			r

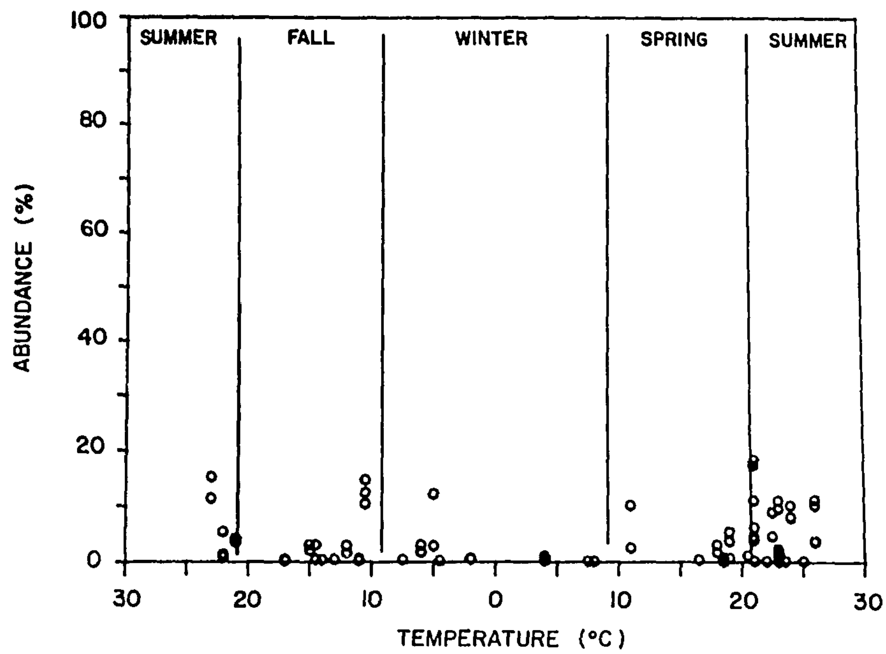

Figure 65. Abundance vs. temperature and season for populations of Nitzschia amphibia

alkalibiontic (Foged, 1948, 1949, 1954; Jorgensen, 1948; Cholnoky, 1968). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1949, 1954, 1968a; Manguin, 1952). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Eurythermal, oligothermal to mesothermal (Scheele, 1952).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Sewage stabilization ponds (Raschke, 1968). Farm ponds (Ohl, 1965). Spirit Lake (Krohn et al., 1974). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974). Soil (Loescher, 1971). Cayler Prairie (Reimer, 1970). Silver Lake Fen (Shobe et al., 1963). Pillsbury and Sylvan lake beds (Hungerford, 1972). Arend's Kettle Hole (Collins, 1968).

Occurrence: Not uncommon in the plankton of the Lake District (Table 199). Perennial species. Oligothermal. Occurs at temperatures between 0° - 25°C. (Figure 65).

Nitzschia angustata (Wm. Smith) Grun. var. *angustata*

Plate: 22, Fig. 2.

Critical reference: Hustedt, 1930a, p. 402, Fig. 767.

Descriptors: Striae, 11 - 12 in 10 µm. Length, 45 - 76 µm. Breadth, 7 - 10 µm. Keel punctae not readily observed

Table 200. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>angustata</u> v. <u>angustata</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake				r	r	r	r	r			
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji			r				r	r			

Table 201. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>capitellata</u> v. <u>capitellata</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake								r	r	o	
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji	r		r			r		r			

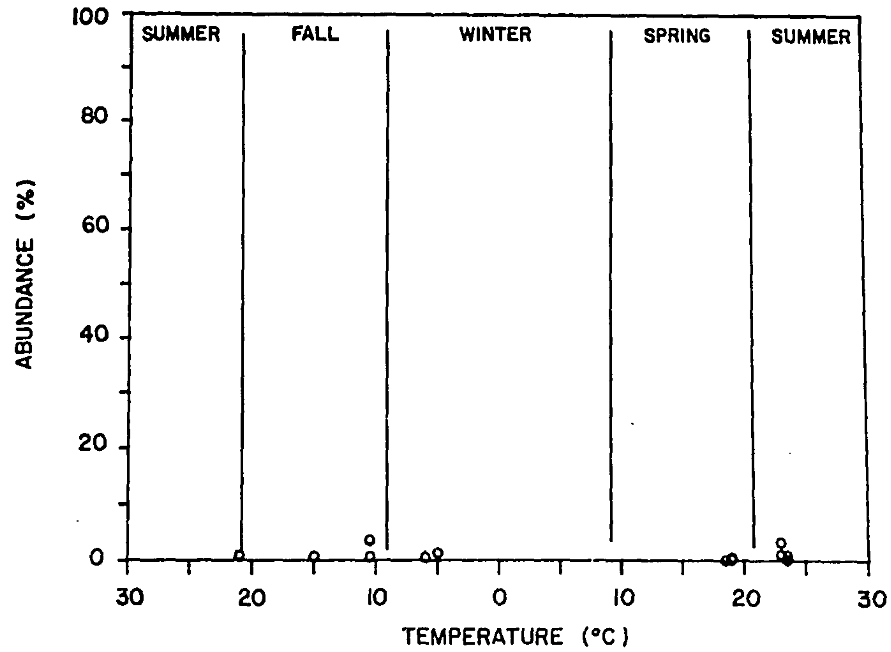

Figure 66. Abundance vs. temperature and season for populations of Nitzschia angustata

with the light microscope.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1953, 1958; Jorgensen, 1948; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Foged, 1948, 1953, 1954, 1968a; Hustedt, 1957). Saproxenous (Hustedt, 1957). Limnophilous (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Des Moines River (Gudmundson, 1969). Spirit Lake (Krohn et al., 1974). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974). Pillsbury and Sylvan lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton of the Lake District (Table 200). No clear indication of periodicity or optimum temperature for growth. Temperature tolerance range 5°- 25°C (Figure 66).

Nitzschia capitellata Hust. var. capitellata

Plate: 22, Fig. 1.

Critical reference: Hustedt, 1930a, p. 414, Fig. 792.

Descriptors: Length, 62.1 µm. Breadth, 5.4 µm. Striae, 33 in 10 µm. Keel punctae, 12 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); tychoplanktonic (Hustedt, 1957); periphytic (Hustedt, 1957). pH indifferent (Hustedt, 1957); alkaliphilous (Foged, 1953; Cholnoky, 1968). Halophilous (Hustedt, 1930a; Petersen, 1943; Foged, 1953); halobion indifferent (Hustedt, 1937 - 1938).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Des Moines River (Gudmundson, 1969). Dutch Creek (Fee, 1967). Coralville Reservoir (Schmidt and Fee, 1967). Skunk River (Shobe, 1967). farm ponds (Ohl, 1965). Cayler Prairie - soils (Reimer, 1970).

Occurrence: Observed in collections from Silver Lake, Spirit Lake, and Lake East Okoboji (Table 201). Rare.

Nitzschia commutata Grun. var. commutata

Plate: 22, Fig. 3.

Critical reference: Hustedt, 1930a, p. 405, Fig. 774.

Descriptors: Striae, 18 in 10 µm. Length, 52 - 65 µm. Breadth, 7 - 11 µm. Keel punctae, 7 - 8 in 10 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977). Insufficiently known.

Previous reports from Iowa: Arend's Kettle Hole (Collins, 1968). Des Moines River (Drum, 1964; Gudmundson, 1969). Dutch Creek (Fee, 1967). Cayler Prairie (Reimer, 1970).

Occurrence: Rare in the plankton of Silver Lake and

Lake West Okoboji (Table 202). No clear indication of periodicity or optimum temperature.

Nitzschia dissipata (Kutz.) Grun. var. dissipata

Plate: 22, Fig. 4.

Critical reference: Hustedt, 1930a, p. 412, Fig. 789.

Descriptors: Striae, not discernible with the light microscope. Length, 32 - 43 μm. Breadth, 3.5 - 4.5 μm. Keel punctae, 7 - 10 in 10 μm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938, Scheele, 1952; Hornung, 1959); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Hustedt, 1957; Foged, 1964) to alkalibiontic (Jorgensen, 1948; Foged, 1947, 1954; Hornung, 1959). Eutrophic (Jorgensen, 1948). Oligohalobic indifferent (Foged, 1948, 1949, 1954; Hustedt, 1957). Rheophilous (Foged, 1948, 1949; Hornung, 1959; Scheele, 1952). Eurythermal and oligothermal to mesothermal (Scheele, 1952).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Lake East Okoboji (Volker, 1963). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Coralville Reservoir (Schmidt and Fee, 1967). Drainage ditches (Lowe, 1970; Edwards, 1974). Dutch Creek (Fee, 1967).

Table 202. Summary of distribution and relative abundance for *Nitzschia commutata* v. *commutata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r							r		
West Okoboji									r	r	
Center Lake											
Spirit Lake											
East Okoboji											

Table 203. Summary of distribution and relative abundance for *Nitzschia dissipata* v. *dissipata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r	r	r	r	r	r	r	
West Okoboji			r	r			r	r	r	r	
Center Lake		r		r	r						
Spirit Lake			r					r	r	r	r
East Okoboji	r	r	r	r		r	o	o			

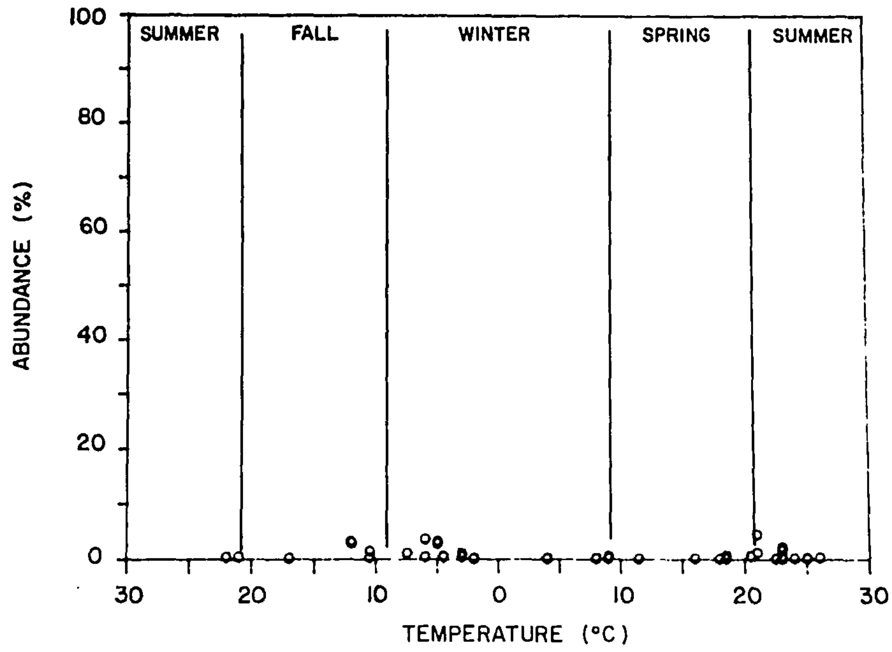

Figure 67. Abundance vs. temperature and season for populations of <u>Nitzschia dissipata</u>

Farm ponds (Ohl, 1965). Subaerial habitats (Stoermer, 1962).

Occurrence: Rare, but frequently observed in the plankton of the Lake District (Table 203). Perennial species, occurring at temperatures from 0°- 25°C (Figure 67). No indication of the optimum temperature for growth.

Nitzschia filiformis (W. Smith) Hust. var. filiformis

Plate: 22, Fig. 5.

Critical reference: Hustedt, 1930a, p. 422, Fig. 818.

Descriptors: Length, 56 µm. Breadth, 4.2 µm. Striae, very fine. Keel punctae, 10-12 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). pH indifferent (Hustedt, 1957). Mesohalobous (Hustedt, 1930a, 1957; Foged, 1948, 1949; Cholnoky, 1968). Euryhalobous (Hustedt, 1930a, 1957). saprophilic (Hustedt, 1957).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Des Moines River (Drum, 1964; Gudmundson, 1969). Drainage ditches (Edwards, 1974).

Occurrence: Rare in the plankton of Lake west Okoboji and Spirit Lake (Table 204).

Nitzschia fontiicola Grun. in V.H. var. fonticola

Plate: 22, Fig. 6.

Critical reference: Hustedt, 1930a, p. 415, Fig. 800.

Descriptors: Striae, 28 - 33 in 10 µm. Length, 18 -

Table 204. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>filiformis</u> v. <u>filiformis</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji										r	
Center Lake											
Spirit Lake				r							
East Okoboji											

Table 205. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>fonticola</u> v. <u>fonticola</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	r	r						
West Okoboji				r	r	r	r		r		
Center Lake											
Spirit Lake			r	a	a	d	d	a	r	r	r
East Okoboji						r	c			r	

31 µm. Breadth, 2.5 - 3.5 µm. Keel punctae, 11 - 13 in 10 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); streams and rivers (Hustedt, 1937 - 1938; Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938; Jorgensen, 1948; Manguin, 19529; euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1953, 1958; Jorgensen, 1948; Cholnoky, 1968) to alkalipbiontic (Hustedt, 1957; Foged, 1964; Cholnoky, 1968). Eutrophic (Jorgensen, 1948). Mesosaprobic (Fjerdingstadt, 1950) to oligosaprobic (Bock, 1952). Current indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965). Sewage stabilization pond (Raschke, 1968).

Occurrence: Rare in the plankton of Silver Lake and Lake West Okoboji, but common in Spirit Lake and Lake East Okoboji (Table 205). Observed during all seasons, but a major component of the plankton during the spring, summer, and fall (Figure 68). Mesothermal, but occurs at temperatures from 0° - 25°C.

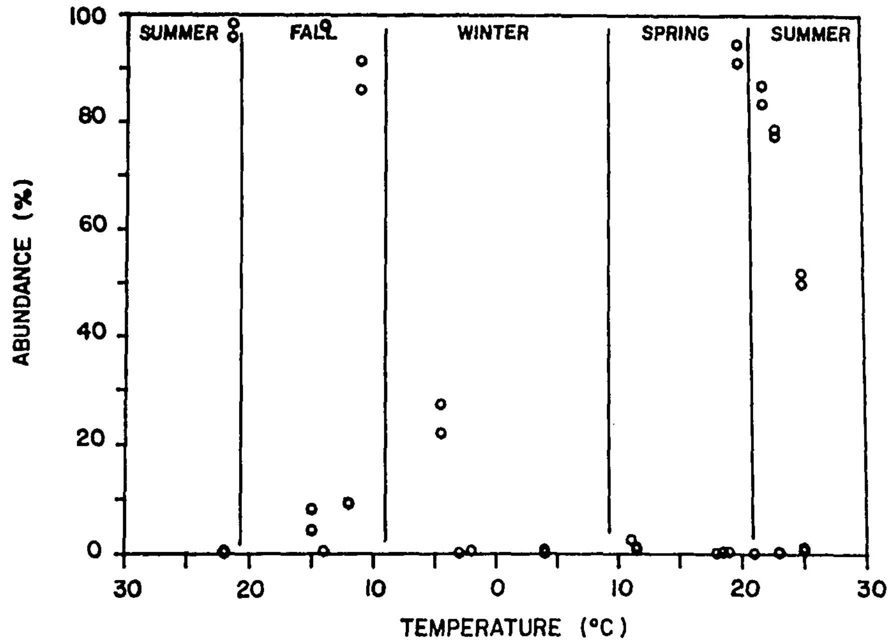

Figure 68. Abundance vs. temperature and season for populations of Nitzschia fonticola

Nitzschia frustulum var. perpusilla

Plate: 22, Fig. 7.

Critical reference: Hustedt, 1930a, p. 415.

Descriptors: Striae, 14 in 10 µm. Length, 18 µm. Breadth, 3.6 µm. Keel punctae, 9 in 10 µm.

Ecology: Freshwater streams and rivers (Collins and Kalinsky, 1977).

Previous reports from Iowa: Skunk River (Roeder, 1976).

Occurrence: Rare in spring plankton of Spirit Lake (Table 206). No clear indication of periodicity or temperature preference.

Nitzschia gracilis Hantz. var. gracilis

Plate: 22, Fig. 8.

Critical reference: Hustedt, 1930a, p. 416, Fig. 794.

Descriptors: Striae not discernible with the light microscope. Length, 52 µm. Breadth, 3 µm. Keel punctae, 14 in 10 µm.

Ecology: Freshwater streams and rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Collins, 1968; Hosseini, 1979). Des Moines River (Drum, 1964; Gudmundson, 1969). Farm ponds (Ohl, 1965).

Occurrence: Rare in Lake West Okoboji (Table 207).

Table 206. Summary of distribution and relative abundance for Nitzschia frustulum v. perpusilla

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake		o									
East Okoboji											

Table 207. Summary of distribution and relative abundance for Nitzschia gracilis v. gracilis

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					r	o	o		r		
Center Lake											
Spirit Lake											
East Okoboji											

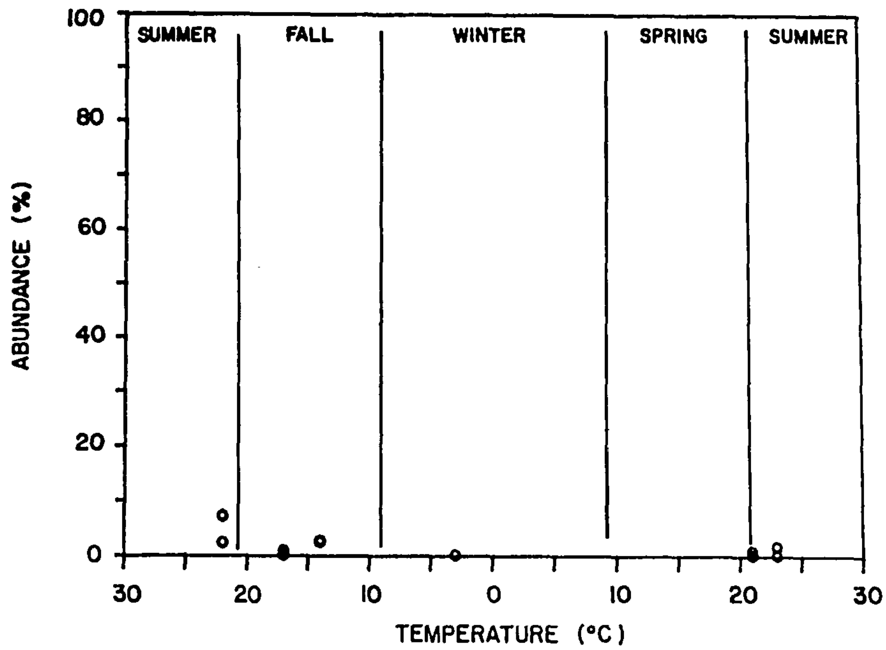

Figure 69. Abundance vs. temperature and season for populations of Nitzschia gracilis

No clear indication of periodicity. Perennial species, occurring at temperatures from 0° - 25° C (Figure 69).

Nitzschia hungarica Grun. var. hungarica

Plate: 22, Fig. 9.

Critical reference: Hustedt, 1930a, p. 401, Fig. 766.

Descriptors: Striae, 10 in 10 μm. Length, 47 μm. Breadth, 5.5 μm. Keel punctae, 12 in 10 μm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Periphytic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1949; Hustedt, 1957). Mesohalobous (Hustedt, 1937 - 1938; Foged, 1948; Manguin, 1952; Cholnoky, 1968) to halophilous (Hustedt, 1937 - 1938, 1957; Raabe, 1951; Scheele, 1952). Current indifferent (Hustedt, 1957) to rheophilous (Foged, 1948).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Coralville Reservoir (Schmidt and Fee, 1967). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974). Pillsbury and Sylvan lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton of Silver Lake (Table 208). No clear indication of periodicity or

Table 208. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>hungarica</u> v. <u>hungarica</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake				r							
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 209. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>intermedia</u> v. <u>intermedia</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											
r											

temperature preference.

Nitzschia intermedia Hantzsch. intermedia

Plate: 26, Fig. 2.

Critical reference: Hustedt, 1949, p. 136, Pl. 13, Figs. 21-23.

Descriptors: Length, 132 µm. Breadth, 7 µm. Striae, 24 in 10 µm. Keel punctae, 8 in 10 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Des Moines River (Gudmundson, 1969). Dutch Creek (Fee, 1967). Coralville Reservoir (Schmidt and Fee, 1967). Farm ponds (Ohl, 1965).

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 209).

Nitzschia kutzingiana Hilse var. kutzingiana

Plate: 22, Fig. 10.

Critical reference: Hustedt, 1930a, p. 416, Fig. 802.

Descriptors: Length, 21 µm. Breadth, 3 µm. Striae, not discernible. Keel punctae, 14 in 10 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977); lakes and ponds (Jorgensen, 1948). Alkaliphilous (Foged, 1948, 1954; Hustedt, 1957). Eutrophic (Jorgensen, 1948). Halobion indifferent (Hustedt, 1957; Foged, 1948,

Table 210. Summary of distribution and relative abundance for <u>Nitzschia kutzingiana</u> v. <u>kutzingiana</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake											
East Okoboji											

Table 211. Summary of distribution and relative abundance for <u>Nitzschia linearis</u> v. <u>linearis</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake r	r	r									
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji	r		r			r		r			

1953). Current indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Drainage ditches (Edwards, 1974).

Occurrence: Rare in a single plankton collection from Lake west Okoboji (Table 210).

Nitzschia linearis (Agardh) Wm. Smith var. linearis

Plate: 24, Fig. 8.

Critical reference: Hustedt, 1930a, p. 409, Fig. 784.

Descriptors: Striae, 22-30 in 10 µm. Length, 106-157 µm. Breadth, 5.4-6.5 µm. Keel punctae, 9-11 in 10 µm.

Ecology: Freshwater rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); springs and streams (Hustedt, 1930a, 1937 - 1938; Manguin, 1952; Scheele, 1952). Periphytic (Blum, 1957; Manguin, 1952). Alkaliphilous (Foged, 1948, 1953, 1954, 1958; Hustedt, 1957). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1953, 1954; Hustedt, 1957). Oligosaprobic (Kolkwitz and Marsson, 1908). Rheobiontic (Foged, 1948, 1954; Hustedt, 1957). Eurythermal and oligothermal to mesothermal (Scheele, 1952). Seasonal maximum - summer (Blum, 1957).

Previous reports from Iowa: Clear Lake (Begres, 1971). Spirit Lake (Krohn et al., 1974). Lake West Okoboji (Hosseini, 1979). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Dutch Creek (Fee, 1967). Farm ponds

(Ohl, 1965). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974).

Occurrence: Observed during all seasons (Table 211). Always rare. Most frequently encountered in Silver Lake and Lake East Okoboji.

Nitzschia palea (Kutz.) Wm. Smith var. *palea*

Plate: 22, Fig. 12.

Critical reference: Hustedt, 1930a, p. 416, Fig. 801.

Descriptors: Striae, 40 in 10 µm, not readily discerned with the light microscope. Length, 26 - 33 µm. Breadth, 3.2 - 4 µm. Keel punctae, 10 - 16 in 10 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Manguin, 1952); tychoplanktonic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). pH indifferent (Foged, 1948, 1954, 1964; Hustedt, 1957). Eutrophic (Hustedt, 1937 - 1938; Jorgensen, 1948; Cholnoky, 1968). Oligohalobous indifferent (Hustedt, 1937 - 1938; Foged, 1948, 1954; Bock, 1952). Mesosaprobic (Hustedt, 1930a, 1937 - 1938; Manguin, 1952; Blum, 1957) to polysaprobic (Hustedt, 1930a, 1957; Blum, 1957). Current indifferent (Foged, 1948, 1954). Eurythermal (Bock, 1952; Scheele, 1952). Seasonal maximum - spring (Schroeder, 1939; Hornung, 1959); summer (Hornung, 1959); fall (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres,

Table 212. Summary of distribution and relative abundance for Nitzschia palea v. palea

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r		r	a	r	r			
West Okoboji					r	r	r				
Center Lake					r						
Spirit Lake		r	r	r							
East Okoboji				r	o	a	c	r			

Table 213. Summary of distribution and relative abundance for Nitzschia pseudoamphioxys v. pseudoamphioxys

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji							r				

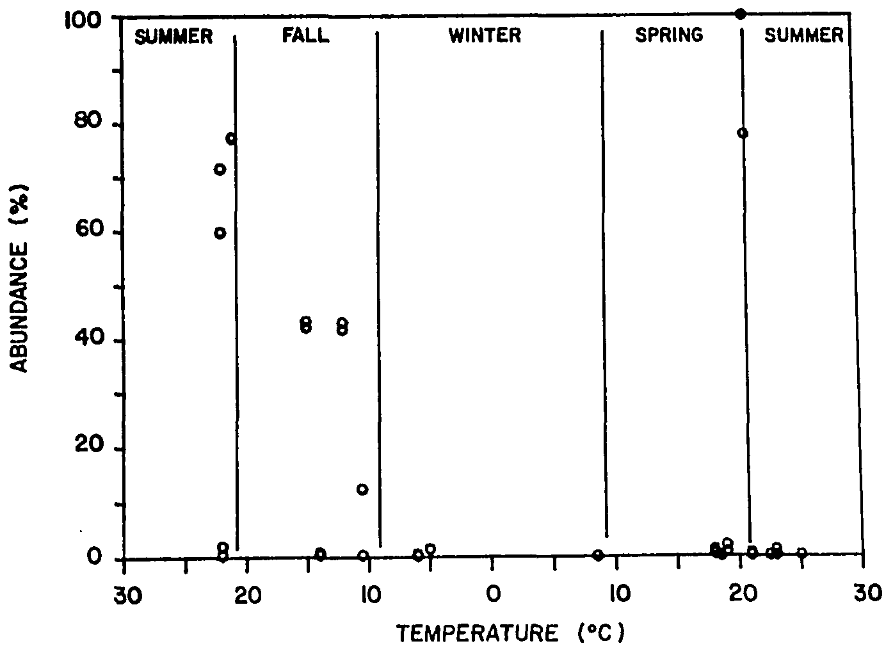

Figure 70. Abundance vs. temperature and season for populations of <u>Nitzschia palea</u>

1971). Lake East Okoboji (Volker, 1963). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Coralville Reservoir (Schmidt and Fee, 1967). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Sewage stabilization pond (Raschke, 1968). Cayler Prairie (Reimer, 1970).

Occurrrence: Not uncommon in the plankton of the Lake District (Table 212). Mesothermal, occurring at temperatures from 5°- 25° C (Figure 70). Most abundant during the spring, summer, and fall.

Nitzschia pseudoamphioxys Hust. *pseudoamphioxys*

Plate: 22, Fig. 13.

Critical reference: Hustedt *ex* Huber-Pestalozzi, 1942, p. 474, Fig. 564a.

Descriptors: Length, 14 µm. Breadth, 4 µm. Striae, 30 in 10 µm. Keel punctae, 10 in 10 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: None.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 213).

Nitzschia recta Hantzsch var. *recta*

Plate: 22, Fig. 11.

Critical reference: Hustedt, 1930a, p. 411, Fig. 785.

Descriptors: Length, 68 µm. Breadth, 5 µm. Striae, fine, not discernible. Keel punctae, 6 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Collins and Kalinsky, 1977).

Previous reports from Iowa: Clear Lake and Ventura Marsh (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964; Fee and Drum, 1965; Gudmundson, 1969). Dutch Creek (Fee, 1967).

Occurrence: Encountered in plankton collections from Silver Lake and Lake East Okoboji (Table 214).

Nitzschia sigma (Kutz.) Wm. Smith var. sigma

Plate: 26, Fig. 3.

Critical reference: Hustedt, 1930a, p. 420, Fig. 813.

Descriptors: Striae, 22 in 10 µm. Length, 156 µm. Breadth, 8 µm. Keel punctae, 7 in 10 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977). Periphytic (Manguin, 1952). Alkalibiontic (Hustedt, 1937 - 1938) to pH indifferent (Foged, 1948; Hustedt, 1957). Mesohalobous (Hustedt, 1920, 1937 - 1938, 1949; Foged, 1948, 1949; Manguin, 1952) to euryhalobous (Hustedt, 1937 - 1938, 1956; Foged, 1948; Manguin, 1952).

Table 214. Summary of distribution and relative abundance for *Nitzschia recta* v. *recta*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake	r										
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji								r	r		

Table 215. Summary of distribution and relative abundance for *Nitzschia sigma* v. *sigma*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake				r							
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji		r									

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). North Twin Lake (Kutkukn, 1958). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Dutch Creek (Fee, 1967). Drainage ditches (Edwards, 1974). Farm ponds (Ohl, 1965).

Occurrence: Rare in the plankton of Silver Lake and Lake East Okoboji (Table 215). No clear indication of periodicity or temperature preference.

Nitzschia sigmoidea (Nitzsch) Wm. Smith var. sigmoidea

Plate: 23, Figs. 4 and 5.

Critical reference: Hustedt, 1930a, p. 419, Fig. 810.

Descriptors: Striae, 22 - 26 in 10 µm. Length, 282 - 350 µm. Breadth, 12.5 - 26 µm. Keel punctae, 6 in 10 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Periphytic (Jorgensen, 1948); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1954, 1958, 1968a; Jorgensen, 1948; Hustedt, 1957). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Hustedt, 1957). Oligosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914; Hustedt, 1957). Current indifferent (Foged, 1948, 1954).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). North Twin Lake (Kutkukn, 1958). Des

Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Edwards, 1974). Farm ponds (Ohl, 1965). Pillsbury and Sylvan lake beds (Hungerford, 1972).

Occurrence: Rare in all the lakes of the District (Table 216). A perennial species occurring at temperatures from 0°- 25°C (Figure 71). No clear indication of temperature preference.

Table 216. Summary of distribution and relative abundance for *Nitzschia sigmoidea* v. *sigmoidea*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake					r		r	r	r	r	r
West Okoboji		r									
Center Lake						r					
Spirit Lake				r							
East Okoboji			r	r		r	r	r			

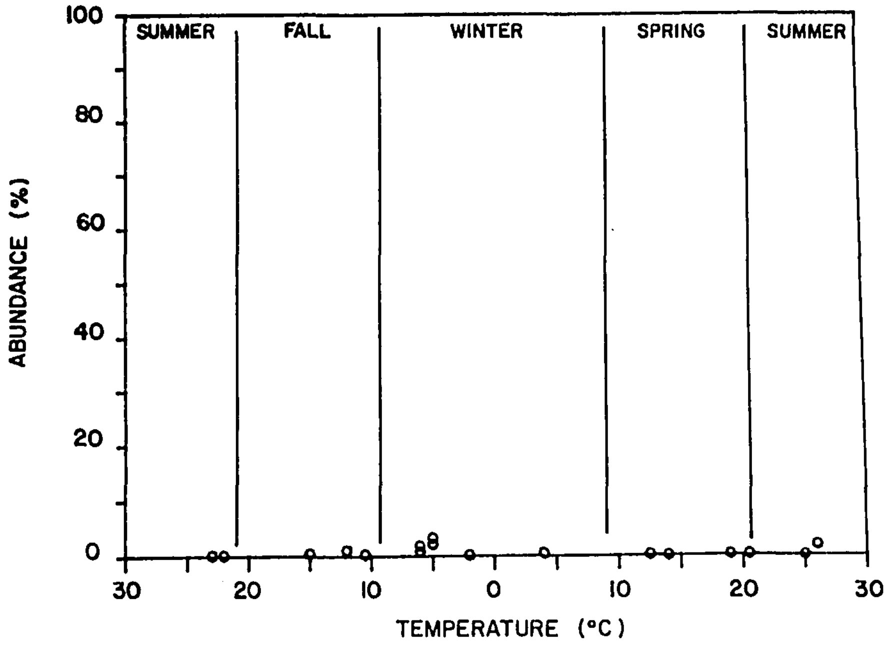

Figure 71. Abundance vs. temperature and season for populations of <u>Nitzschia sigmoidea</u>

Table 217. Summary of distribution and relative abundance for <u>Nitzschia sinuata</u> v. <u>tabellaria</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											r

Nitzschia sinuata var. tabellaria Grun.

Plate: 22, Fig. 14.

Critical reference: Hustedt, 1930a, p., 409, Fig. 782.

Descriptors: Striae, 24 in 10 µm. Length, 15 µm. Breadth, 5.2 µm. Keel punctae, 6 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Lake East Okoboji (Volker, 1963). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965).

Occurrence: Rare in the spring plankton of Lake East Okoboji (Table 217). No clear indication of periodicity or temperature preference.

Nitzschia subrostratoides Cholnoky var. subrostratoides

Plate: 23, Fig. 1.

Critical reference: Cholnoky, 1966, p. 59, Pl. 6, Fig. 171-173.

Descriptors: Length, 44.1 µm. Breadth, 3.2 µm. Striae, fine not determined. Keel punctae, 13-15 in 10 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: None.

Occurrence: Rare in a single plankton sample from Spirit Lake (Table 218).

Table 218. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>subrostratoides</u> v. <u>subrostratoides</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake				r							
East Okoboji											

Table 219. Summary of distribution and relative abundance for <u>Nitzschia</u> <u>subtilioides</u> v. <u>subtilioides</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r						r		
West Okoboji		r									
Center Lake											
Spirit Lake		r									
East Okoboji			r				r				

Nitzschia subtilioides Hust. var. subtilioides

Plate: 26, Fig. 4.

Critical reference: Hustedt, 1959a, p. 438, Figs. 9-13.

Descriptors: Length, 130 µm. Breadth, 6 µm. Striae, very fine, >35 in 10 µm. Keel punctae, 10 in 10 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: Clear Lake and Ventura Marsh (Begres, 1971).

Occurrence: Observed in plankton samples from all of the lakes except Center Lake (Table 219). Always rare.

Nitzschia tryblionella var. levidensis (Wm. Smith) Grun.

Plate: 23, Fig. 2.

Critical reference: Hustedt, 1930a, p. 399, Fig. 760.

Descriptors: Striae, 9 - 13 in 10 µm. Length, 12 - 39 µm. Breadth, 3.5 - 9 µm. Keel punctae, 9 - 10 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969). Farm ponds (Ohl, 1965). Drainage ditches (Edwards, 1974).

Occurrence: Observed in a single summer plankton

Table 220. Summary of distribution and relative abundance for Nitzschia tryblionella v. levidensis

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake											
East Okoboji											

Table 221. Summary of distribution and relative abundance for Nitzschia vermicularis v. vermicularis

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji		r									
Center Lake											
Spirit Lake											
East Okoboji											

sample from Lake West Okoboji (Table 220). No clear indication of periodicity or temperature preference.

Nitzschia vermicularis (Kutz.) Hantz. in Rabh. var. vermicularis

Plate: 26, Fig. 5.

Critical reference: Hustedt, 1930a, p. 419, Fig. 811.

Descriptors: Striae, 35 in 10 µm. Length, 140 µm. Breadth, 6.3 µm. Keel punctae, 10 in 10 µm.

Ecology: Freshwater lakes (Jorgensen, 1948); rivers (Collins and Kalinsky, 1977). Periphytic (Jorgensen, 1948). pH indifferent (Foged, 1948, 1954) to alkaliphilous (Hustedt, 1957; Cholnoky, 1968). Oligotrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948; Hustedt, 1957) to halophilous (Foged, 1949). Oligosaprobic (Kolkwitz and Marsson, 1908; Manguin, 1952; Hustedt, 1957). Current indifferent (Foged, 1948).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Des Moines River (Drum, 1964). Dutch Creek (Fee, 1967). Drainage ditches (Lowe, 1970). Farm ponds (Ohl, 1965).

Occurrence: Rare in the plankton of Lake West Okoboji (Table 221). No clear indication of periodicity or temperature preference.

Nitzschia sp. 1

Plate: 26, Fig. 1.

Descriptors: Length, 179 µm. Breadth, 6 µm. Striae, $\geq$ 30 in 10 µm. Keel punctae, 8-9 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 222).

Nitzschia sp. 2

Plate: 22, Fig. 15.

Descriptors: Length, 30 µm. Breadth, 3 µm. Striae, 28 in 10 µm. Keel punctae, 12 in 10 µm.

Occurrence: Rare in the plankton of Lake West Okoboji and Spirit Lake (Table 223).

Nitzschia sp. 3

Plate: 23, Fig. 3.

Descriptors: Length, 48.6 µm. Breadth, 4 µm. Striae, > 33 in 10 µm. Keel punctae, 12 in 10 µm.

Occurrence: Rare in the fall plankton of Lake West Okoboji (Table 224).

Opephora martyi Heribaud var. *martyi*

Plate: 10, Figs. 3 and 7.

Critical reference: Patrick and Reimer, 1966, p. 115, Pl. 3, Fig. 3.

Descriptors: Striae, 4 - 9 in 10 µm. Length, 13.5 - 40 µm. Breadth, 3.5 - 8 µm.

Ecology: Freshwater lakes (Raabe, 1951; Patrick and Reimer, 1966; Stoermer and Yang, 1969); rivers (Patrick and

Table 222. Summary of distribution and relative abundance for *Nitzschia* sp. 1

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji								r			

Table 223. Summary of distribution and relative abundance for *Nitzschia* sp. 2

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake											
Spirit Lake					r	r	r				
East Okoboji											

Table 224. Summary of distribution and relative abundance for <u>Nitzschia</u> sp. 3

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji						r	r				
Center Lake											
Spirit Lake											
East Okoboji											

Table 225. Summary of distribution and relative abundance for <u>Opephora</u> <u>martyi</u> v. <u>martyi</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				r	r						
Center Lake											
Spirit Lake			r				r				
East Okoboji											

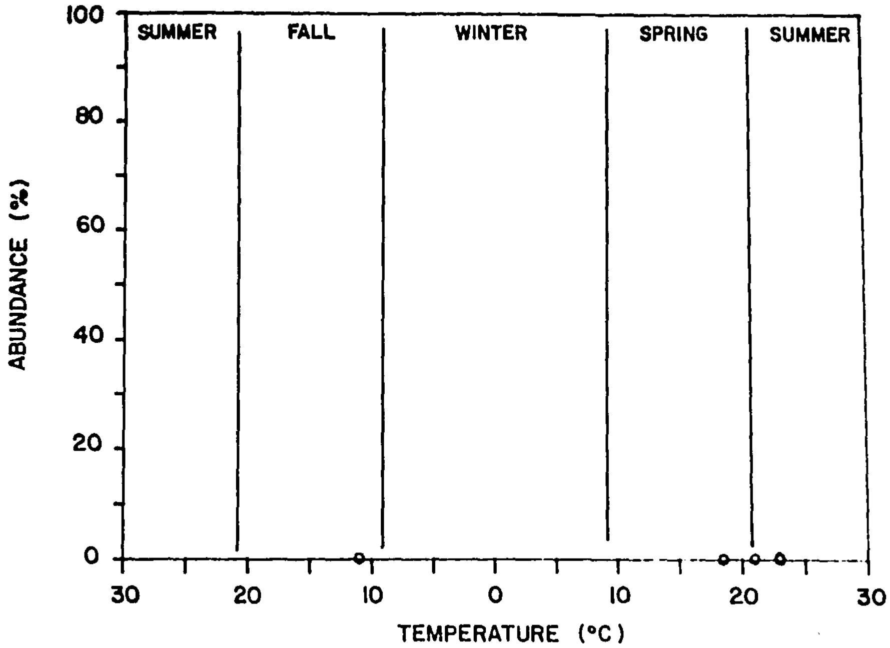

Figure 72. Abundance vs. temperature and season for populations of Opephora martyi

Reimer, 1966; Collins and Kalinsky, 1977). Periphytic (Raabe, 1951; Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkalipilous (Foged, 1958, 1964, 1968a; Hustedt, 1957; Cholnoky, 1968) to alkalibiontic (Foged, 1948, 1954; Jorgensen, 1948). Eutrophic (Jorgensen, 1948) to mesotrophic (Patrick and Reimer, 1966). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Hustedt, 1957). Limnophilous (Foged, 1948, 1954).

Prevous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964).

Occurrence: Rare in the plankton of Lake West Okoboji and Spirit Lake (Table 225). No clear indication of periodicity or temperature preference (Figure 72). Temperture range 10° - 25°C.

Pinnularia brebissonii (Kutz.) Rabh. var. *brebissonii*

Plate: 17, Fig. 6.

Critical reference: Patrick and Reimer, 1966, p. 614, Pl. 58, Fig. 6.

Descriptors: Striae, 7 in 10 μm. Length, 35 μm. Breadth, 8 μm.

Ecology: Freshwater form, lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Olighalobous indifferent (Foged, 1948; 1954). pH indifferent (Foged, 1948; 1954, 1964). Rheophilous (Foged, 1948, 1954). Prefers cool water of low mineral content (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Jackson, 1980). Dead Man's Lake (Christensen, 1976; Jackson, 1980). Big Wall Lake, Little Wall Lake, Rice Lake, Three Corner Ponds (Jackson, 1980). Des Moines River (Drum, 1964; Gudmundson, 1969; Jackson, 1980). Drainage ditches (Jackson, 1980). Soil (Hayek and Hulbary, 1956). Cayler Prairie (Reimer, 1970). South Falls (Stoermer, 1962). Pillsbury and Sylvan lake beds (Hungerford, 1972). Pea's Creek, Little Sioux River, Dugout Creek, Iowa River, Mill Creek, Cedar River, Winnebago River, Shell Rock River, Walnut Creek, Tarkio River, Tarkio Creek, Volga River, Maquoketa River, Whitebreast Creek, Skunk River, Grand River, Platte River, Nodaway River, Nishnabotha River, Silver River (Jackson, 1980). Arend's Kettle Hole (Collins, 1968).

Occurrence: Rare in the summer plankton of Spirit Lake (Table 226). No clear indication of periodicity or optimum temperature for occurrence.

Pinnularia maior (Kutz.) Rabh. var. maior

Plate: 17, Fig. 3.

Critical reference: Patrick and Reimer, 1966, p. 629, Pl. 61, Fig. 4.

Descriptors: Striae, 7 in 10 µm. Length, 165 µm. Breadth, 27 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969);

Table 226. Summary of distribution and relative abundance for *Pinnularia brebissonii* v. *brebissonii*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake				r							
East Okoboji											

rivers (Collins and Kalinsky, 1977). Widely distributed in water of fairly low mineral content (Patrick and Reimer, 1966).

Previous reports from Iowa: North Twin Lake (Kutkukn, 1958). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965). Dead Man's Lake (Christensen, 1976).

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 227).

Table 227. Summary of distribution and relative abundance for *Pinnularia maior* v. *maior*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji							r				

Pinnularia viridis (Nitz.) Ehr. var. viridis

Plate: 17, Fig. 4.

Critical reference: Patrick and Reimer, 1966, p. 639, Pl. 64, Fig. 5.

Descriptors Striae, 7 in 10 µm. Length, 86.5 µm. Breadth, 16.2 µm.

Ecology: Freshwater form, lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969); periphytic (Manguin, 1952). Oligohalobous (Hustedt, 1937 - 1938) or oligohalobous indifferent (Foged, 1948, 1954, Hustedt, 1957). Oligosaprobous (Hustedt, 1957). pH indifferent (Foged, 1948; 1954, 1964; Hustedt, 1957). Current indifferent (Foged, 1948, 1954). Found in water with higher mineral content than tolerated by many Pinnularia species (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971; Jackson, 1980). Lake West Okoboji (Stoermer, 1963a; Jackson, 1980). Lake East Okoboji (Volker, 1963). Crystal Lake (Jackson, 1980). Lake Minnewashta (Jackson, 1980). Mud Lake (Jackson, 1980). Dead Man's Lake (Christensen, 1976; Jackson, 1980). Big Wall Lake (Jackson, 1980). Freda Haffner Kettle Hole (Jackson, 1980). Jemmerson Slough (Jackson, 1980). Three Corners Ponds (Jackson, 1980). Des Moines River (Starrett and Patrick, 1952; Drum, 1964). Dutch Creek (Fee,

Table 228. Summary of distribution and relative abundance for *Pinnularia viridis* v. *viridis*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake							r				
West Okoboji											
Center Lake					r						
Spirit Lake											
East Okoboji											

Table 229. Summary of distribution and relative abundance for *Pinnularia* sp. 1

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											r

1967). Skunk River (Roeder, 1976; Beckert, 1977; Jackson, 1980). Pillsbury and Sylvan lake beds (Hungerford, 1972). Arend's Kettle Hole (Collins, 1968). Little Sioux River, Dugout Creek, Mill Creek, Iowa River, Maquoketa River, Cedar River, Little Cedar River, Big Cedar Creek, Winnebago River, Shell Rock River, Volga River, Wapsipinicon River, Chariton River, Grand River, Tarkio River, Walnut Creek, Nodaway River, Thompson River (Jackson, 1980). Drainage ditches (Lowe, 1970; Edwards, 1974; Jackson, 1980). Cayler Prairie (Reimer, 1970). Excelsior Fen. (Shobe et al., 1963).

Occurrence: Observed in the summer and fall plankton of Silver Lake and Center Lake, but always rare (Table 228). No clear pattern of periodicity or temperature preference.

Pinnularia sp. 1

Plate: 17, Fig. 7.

Descriptors: Length, 42 µm. Breadth, 7 µm. Striae, 19 in 10 µm.

Occurrence: Rare in a single plankton sample from Lake East Okoboji (Table 229).

Rhoicosphenia curvata (Kutz.) Grun. *ex* Rabh. var. *curvata*

Plate: 23, Figs. 6 and 8.

Critical reference: Patrick and Reimer, 1966, p. 282, Pl. 20, Figs. 1 - 5.

Descriptors: Striae, 10 - 13 in 10 µm on both valves.

Length, 12 - 25 μm. Breadth, 5 - 6 μm.

Ecology: Freshwater form, lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Scheele, 1952); epiphytic (Jorgensen, 1948; Cholnoky, 1968). Alkaliphilous (Foged, 1948; 1954; 1968a; Jorgensen, 1948; Hustedt, 1957). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Jorgensen, 1948; Foged, 1948; 1949; 1954; 1968a). Mesosaprobic (Kolkwitz, 1914, Fjerdingstadt, 1950,; Foged, 1968b). Current indifferent (Foged, 1948, 1954; Scheele, 1952) to rheophilous (Fjerdingstadt, 1950; Hustedt, 1957; Foged, 1968b). Eurthermal (Scheele, 1952). Seasonal maximum - spring (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hostetter and Stoermer, 1968; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Des Moines River (Drum, 1964; Gudmundson, 1969). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage Ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Excelsior Fen (Shobe et al., 1963).

Occurrence: Perennial species, observed in plankton samples from all the lakes (Table 230). Occurred at temperatures from 0° - 25°C (Figure 73). No clear indication of the optimum temperature for growth.

Table 230. Summary of distribution and relative abundance for Rhoicosphenia curvata v. curvata

Lake	1979 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	1980 Jan	Mar	Apr
Silver Lake			o	r	r	r	o	r			
West Okoboji		r		r		r		r	r		r
Center Lake				r							
Spirit Lake							r				
East Okoboji		r		r			r	r	r		

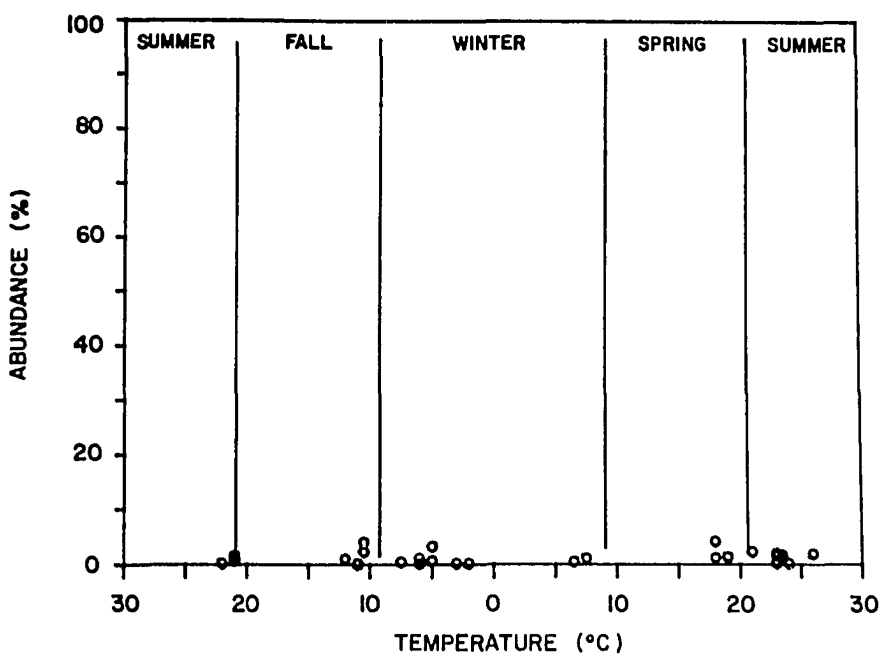

Figure 73. Abundance vs. temperature and season for populations of Rhoicosphenia curvata

Rhopalodia gibba (Ehr.) O. Muller var. gibba

Plate: 23, Fig. 7.

Critical reference: Patrick and Reimer, 1975, p. 189, Pl. 28, Fig. 1.

Descriptors: Costae, 7 - 8 in 10 µm. Rows of alveoli, 2 - 3 between each pair of costae. Length, 90 µm. Breadth, 9 - 10 µm.

Ecology: Freshwater form, lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977); springs and streams (Hustedt, 1937 - 1938; Manguin, 1952). Periphytic (Hustedt, 1937 - 1938; Raabe, 1951); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948; 1949, 1954, 1958; Jorgensen, 1948) to alkalibiontic (Hustedt, 1937 - 1938, 1957; Foged, 1964, 1968a; Cholnoky, 1968). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Hustedt, 1937 - 1938, 1957; Foged, 1948, 1949, 1954, 1968a). Alpha-mesosaprobic (Fjerdingstadt, 1950) to oligosaprobic (Kolkwitz and Marsson, 1908). Current indifferent (Foged, 1948, 1953). Seasonal maximum - winter (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Arend's Kettle Hole (Collins, 1968). Pillsbury and Sylvan lake beds (Hungerford, 1972). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder,

Table 231. Summary of distribution and relative abundance for <u>Rhopalodia</u> <u>gibba</u> v. <u>gibba</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake								r			
East Okoboji											

1976; Beckert, 1977). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Excelsior Fen (Shobe et al., 1963). Arend's Kettle Hole (Collins, 1968).

Occurrence: Rare in the winter plankton of Spirit Lake (Table 231). No clear indication of periodicity or temperature preference.

Stephanodiscus hantzschii Grun. var. *hantzschii*

Plate: 3, Figs. 9, 11 and 12. Plate 7, Figs. 5 and 6. Plate 8, Figs. 1, 2, 3 and 5.

Critical reference: Hustedt, 1930a, p. 110, Fig. 87.

Descriptors: Diameter, 8-12 µm. Spines, 8-10 in 10 µm around the margin of the valve.

Ecology: Freshwater lakes (Jorgensen, 1948; Cholnoky, 1968; Stoermer and Yang, 1969). Euplanktonic (Jorgensen, 1948; Cholnoky, 1968; Stoermer and Yang, 1969). Alkaliphilous (Hustedt, 1957; Cholnoky, 1968; Foged, 1968b); Alkalibiontic (Foged, 1948, 1949; Jorgensen, 1948). Eutrophic (Hustedt, 1937 - 1938; Jorgensen, 1948; Cholnoky, 1968). Oligohalobous (Kolbe, 1927; Hustedt, 1957); oligohalobous - indifferent (Cupp, 1943; Foged, 1949, 1954). Current - indifferent (Foged, 1949, 1954); rheophilous (Raabe, 1951). Seasonal maximum - spring (Raabe, 1951).

Occurrence: A common species within all the lakes

Table 232. Summary of distribution and relative abundance for <u>Stephanodiscus</u> <u>hantzschii</u> v. <u>hantzschii</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake	a	c	c	c	o	r	r	r	r		
West Okoboji		c	r	c	c	o	c	r	c	a	o
Center Lake	r	c	r	r	r	r		r			r
Spirit Lake	c	r	r	r	r		r	r	c	o	
East Okoboji	a	a	a	o	o	o	o	r	o	c	r

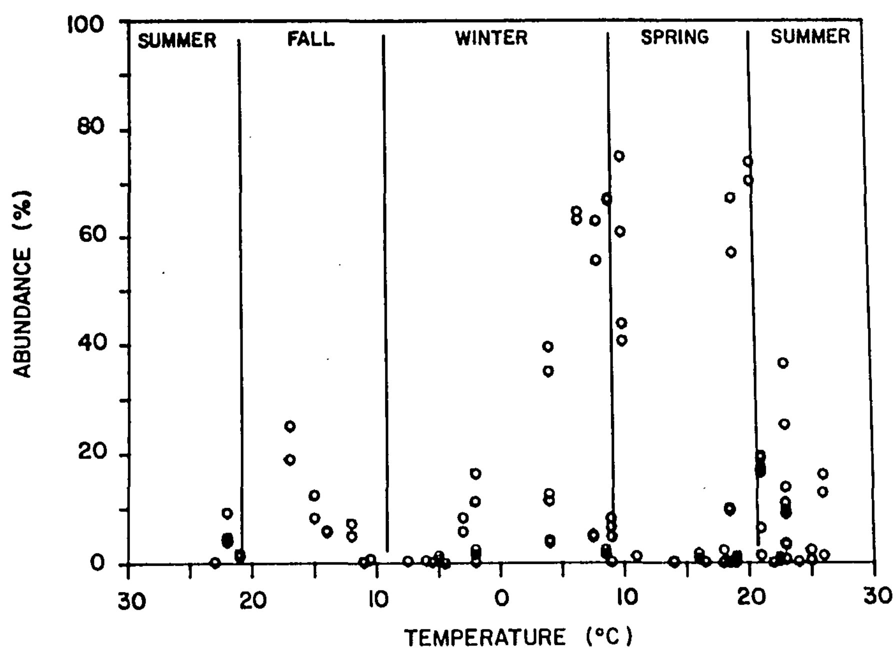

Figure 74. Abundance vs. temperature and season for populations of <u>Stephanodiscus</u> <u>hantzschii</u>

(Table 232). Perennial, most abundant during the early spring and summer (Figure 74). Greatest development at temperatures between 5°and 20° C.

Stephanodiscus minutus Grun. ex Cleve and Moll. var. minutus

Plate: 2, Fig. 6, 7 and 8. Plate 8, Fig. 6.

Critical reference: Hustedt 1930a, p. 110, Fig. 86.

Descriptors: Cells 8-15 μm in diameter. Spines, 15-16 in 10 μm.

Ecology: Freshwater lakes (Hustedt, 1949; Raabe, 1951; Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Alkaliphilous (Foged, 1968a); alkaliontic (Foged, 1948, 1949, 1954, 1964; Hustedt, 1957). Oligohalobous (Hustedt, 1957); oligohalobous-indifferent (Petersen, 1943); Foged, 1948, 1964). Saproxenous (Hustedt, 1957). Current indifferent (Foged, 1948); rheophilous (Foged, 1954). Euplanktonic (Hustedt, 1949; Raabe, 1951).

Previous reports from Iowa: Lake East Okoboji (Volker, 1963); Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969).

Occurrence: Common taxon within the Region, perennial (Table 233). Greatest abundance observed during the winter and early spring (Figure 75), when temperatures are between 5° and 10°C.

Table 233. Summary of distribution and relative abundance for Stephanodiscus minutus v. minutus

	1979								1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake	c	c	c	r	r	r	r	r			
West Okoboji		c	o	c	o	o	c	r	o	a	o
Center Lake	c	c	r	o	r	r	r	r			
Spirit Lake	a	o	r	o	r	r	r	r	a	c	r
East Okoboji	c	c	o	r	r	r	r		r	o	

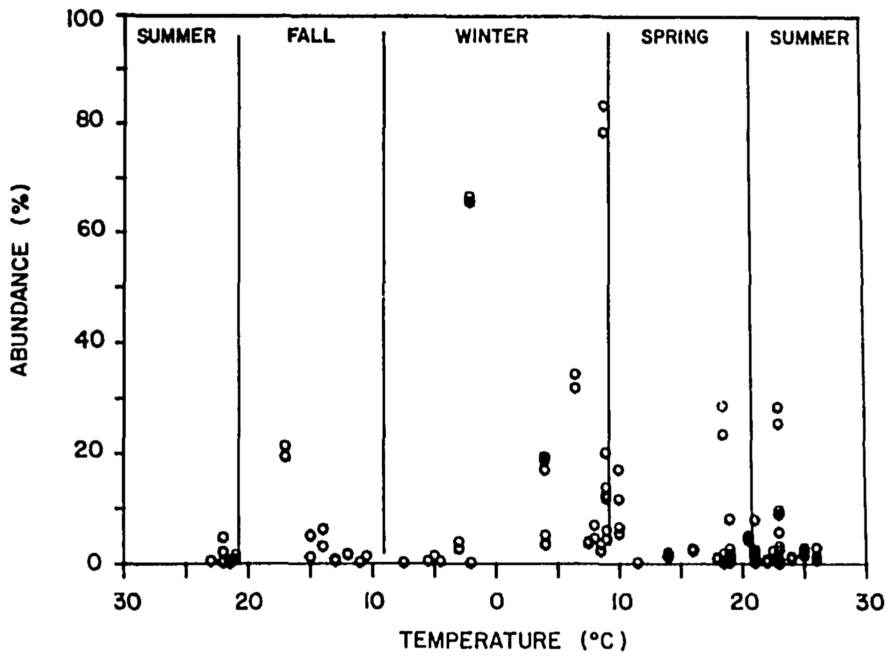

Figure 75. Abundance vs. temperature and season for populations of Stephanodiscus minutus

Stephanodiscus niagarae v. niagarae

Plate: 3, Figs. 3 and 4. Plate 4, Figs. 1 - 4. Plate 5, Figs. 1 and 2.

Critical reference: Schmidt, 1874 - 1959, Figs. 1 - 9.

Descriptors: Diameter, 20 - 30 µm. Spines, 3 in 10 µm of the valve circumference. Fascicles, 5 - 7 in 10 µm of the valve circumference.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hostetter and Stoermer, 1968; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). North Twin Lake (Kutkukn, 1958). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Coralville Reservoir (Schmidt and Fee, 1967). Farm ponds (Ohl, 1965).

Occurrence: Not uncommon in the plankton of the Lake District (Table 234). Observed in the greatest abundance during the spring, summer, and fall. Occurred at temperatures from 0° - 25°C (Figure 83).

Stephanodicus niagare var. magnifica Fricke

Plate: 3, Fig. 1 and 2. Plate 5, Fig. 3 and 4. Plate 6, Fig. 1 through 4.

Table 234. Summary of distribution and relative abundance for *Stephanodiscus niagarae* v. *niagarae*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake	r	o	r	c	o	r	r	o			
West Okoboji				r							
Center Lake	r	r	c	c	c	c	o	c	r		o
Spirit Lake											r
East Okoboji		r	r	r	r	r	o	r			

Table 235. Summary of distribution and relative abundance for *Stephanodiscus niagare* v. *magnifica*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake			r	o							r
West Okoboji			r	r	r		c				
Center Lake			o	o	r						
Spirit Lake		r		o	r		r	r			
East Okoboji											

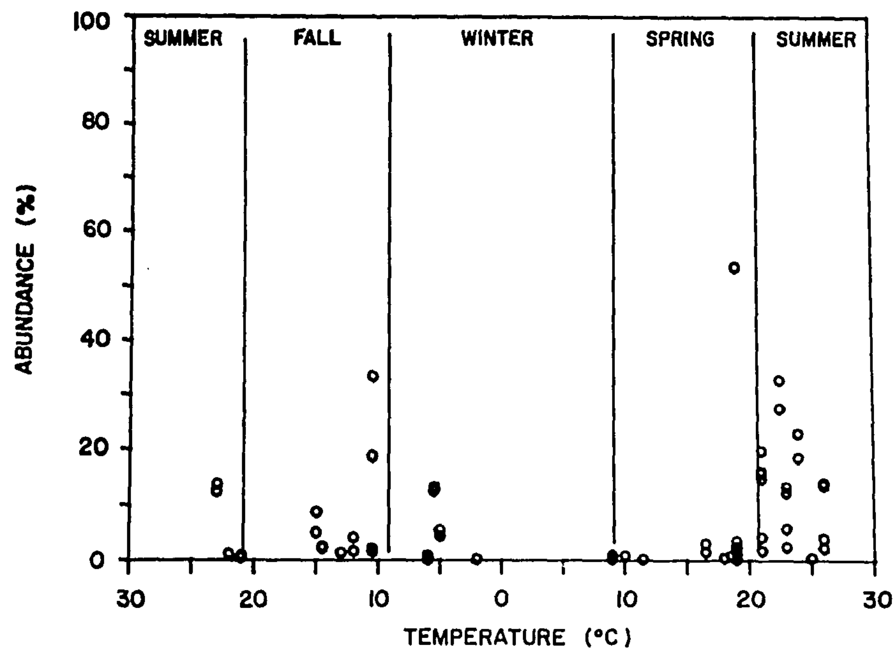

Figure 76. Abundance vs. temperature and season for populations of Stephanodiscus niagarae

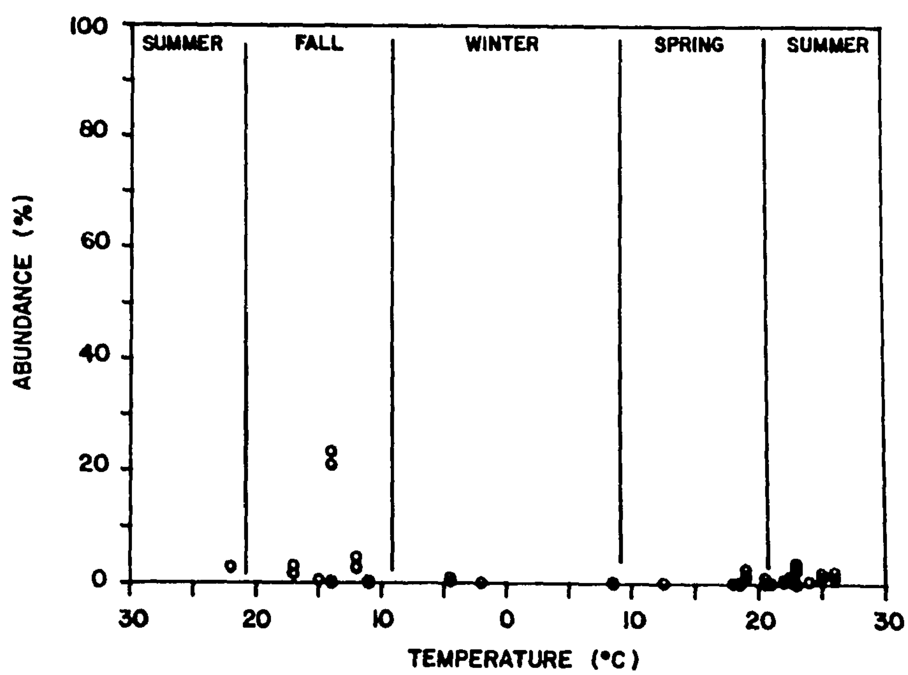

Figure 77. Abundance vs. temperature and season for populations of Stepanodiscus niagarae v. magnifica

Critical reference: Schmidt, 1874 - 1959, Pl. 227, Figs. 12, 13.

Descriptors: Diameter, 30 - 80 µm. Spines, 2 - 3 in 10 µm of the valve circumference. Fascicles, 3 - 6 in 10 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a, 1964; Collins, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963).

Occurrence: Less common than the nominate variety, usually rare (Table 235). Observed in samples from all the lakes except Lake East Okoboji. Typically, a summer and fall species (Figure 77). Mesothermal.

Stephanodiscus tenuis Hust. var. *tenuis*

Plate: 3, Figs. 5 - 8, 9a, 10, 13 and 14. Plate 7, Figs. 1 - 4. Plate 8, Fig. 4.

Critical reference: Hustedt, 1942, *ex* Huber-Pestalozzi, p. 411, Pl. 122, Fig. 506.

Descriptors: Diameter, 6-13 µm. Spines, 6-7 in 10 µm around the margin of the valve.

Ecology: Freshwater lakes (Holland, 1969; Stoermer and Yang, 1969; Holland and Beeton, 1972). Euplanktonic (Stoermer and Yang, 1969). Eutrophic (Stoermer and Yang, 1970; Holland and Beeton, 1972).

Previous reports from Iowa: None.

Occurrence: Common species throughout the Lake District (Table 236). No clear indication of optimum temperature range (Figure 78). Perennial, greatest abundance during the late winter.

Table 236. Summary of distribution and relative abundance for *Stephanodiscus tenuis* v. *tenuis*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake	c	c	o	r	r	r	r			r	
West Okoboji			r	r	c	r	r	r	r	r	
Center Lake	r	o		o	r	r		r			r
Spirit Lake	o	r	r	r	r				c	c	o
East Okoboji	o	o	o	r	r	r	o		r	r	

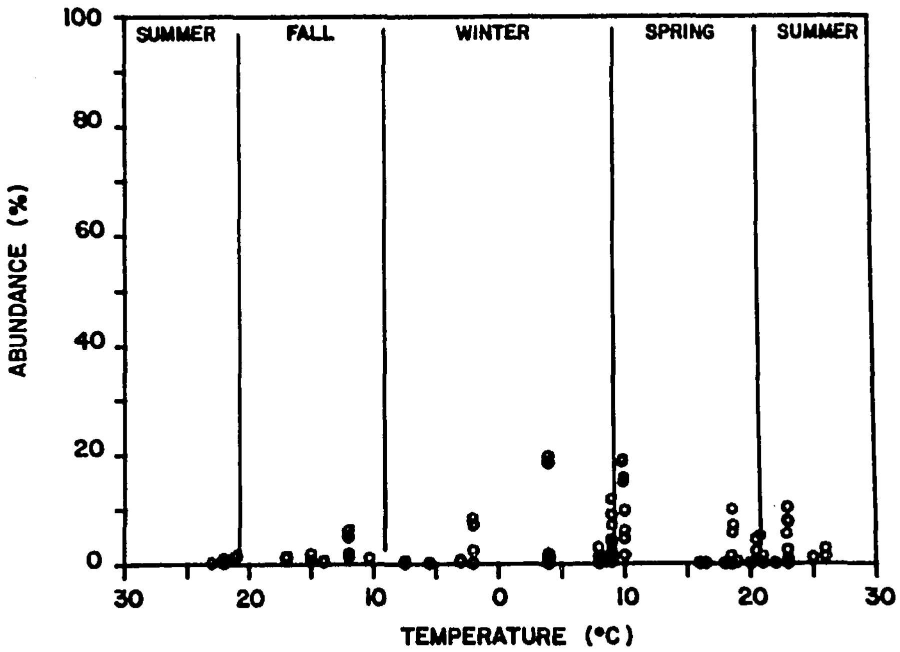

Figure 78. Abundance vs. temperature and season for populations of Stephanodiscus tenuis

Table 237. Summary of distribution and relative abundance for Surirella angusta v. angusta

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake		r			r		r		r	r	
West Okoboji										r	
Center Lake					r						
Spirit Lake				r							
East Okoboji			r	r			r				

Surirella angusta Kutz. var. angusta

Plate: 24, Fig. 1.

Critical reference: Hustedt, 1930a, p. 435, Figs. 844 - 845.

Descriptors: Striae, very fine. Keel canals 6 - 7 in 10 µm. Length, 50 - 60 µm. Breadth, 10 - 12 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); springs (Hustedt, 1937 - 1938; Manguin, 1952; Scheele, 1952). Periphytic (Schroeder, 1939; Manguin, 1952); tychoplanktonic (Schroeder, 1939; Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948; 1954; 1958; Bock, 1952; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Schroeder, 1939; Foged, 1948, 1949, 1954; Hustedt, 1957). Rheobiontic (Foged, 1948, 1954; Manguin, 1952). Mesothermal to eurythermal (Scheele, 1952). Seasonal maximum - spring (Hornung, 1959); fall (Schroeder, 1939).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976; Beckert, 1977). Coralville Reservoir (Schmidt and Fee, 1967). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen,

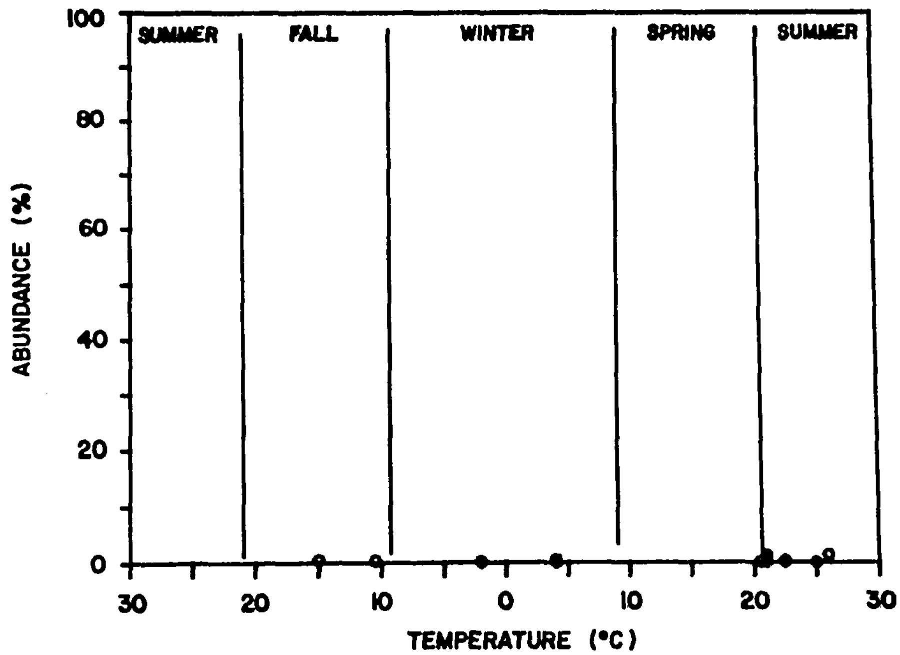

Figure 79. Abundance vs. temperature and season for populations of Surirella angusta

Table 238. Summary of distribution and relative abundance for Surirella biseriata v. punctata

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake				o			r	r			
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji											

1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Soil (Hayek and Hulbary, 1956). Pillsbury and Sylvan lake beds (Hungerford, 1972).

Occurrence: A perennial species, rare in the plankton of the Lake District (Table 237). No clear indication of optimum temperature range, but occurred at temperatures from 0^{o}- 25^{o}C (Figure 79).

Surirella biseriata f. punctata Meister

Plate: 25, Fig. 3.

Critical reference: Cleve-Euler, 1952, p. 105, Fig. 1528c.

Descriptors: Striae very fine. Keel canals, 1 - 2 in 10 µm. Length, 73.5 - 134 µm. Breadth, 28 - 44 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: Spirit Lake (Krohn et al., 1974). Clear Lake (Begres, 1971). Skunk River (Beckert, 1977).

Occurrence: Rare in the plankton of the Lake District (Table 238). No clear indication of periodicity, but occurring at temperatures between 5^{o} - 25^{o}C (Figure 80).

Surirella guatimalensis ehr. var. guatimalensis

Plate: 24, Fig. 3.

Critical reference: Boyer, 1916, p. 126, Pl. 36, Fig. 5.

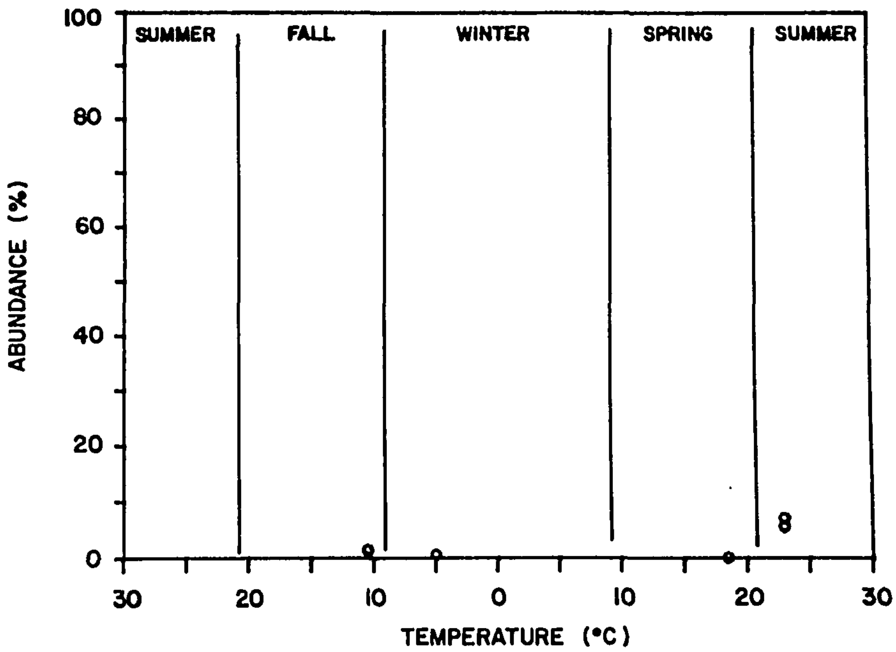

Figure 80. Abundance vs. temperature and season for populations of Surirella biseriata f. punctata

Table 239. Summary of distribution and relative abundance for Surirella guatimalensis v. guatimalensis

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji			r								
Center Lake											
Spirit Lake											
East Okoboji											

Descriptors: Striae, fine. Keel canals, 3 in 10 µm. Length, 167 µm. Breadth, 88 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a).

Occurrence: Rare species, observed in a single, spring plankton sample from Lake West Okoboji (Table 239). No clear indication of periodicity or optimum temperature for growth.

Surirella iowensis Stoermer var. *iowensis*

Plate: 23, Fig. 10.

Critical reference: Lowe, 1972, p. 69, Pl. v, Fig. 2,3.

Descriptors: Striae, 18 in 10 µm. Length, 20 - 30 µm. Breadth, 10 - 12 µm.

Ecology: Insufficiently known.

Previous reports from Iowa: Drainage ditches (Lowe, 1970, 1972, 1973). Stoermer (1963a) reports this taxon to be widely distributed in Iowa, including lakes East and West Okoboji, Silver Lake Fen, Des Moines River, Little Sioux River, and Squaw Creek. Skunk River (Roeder, 1976).

Occurrence: Rare in the plankton of Silver Lake and Lake West Okoboji (Table 240). No clear indication of

Table 240. Summary of distribution and relative abundance for *Surirella iowensis* v. *iowensis*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake							r		r	r	
West Okoboji					r						
Center Lake											
Spirit Lake											
East Okoboji											

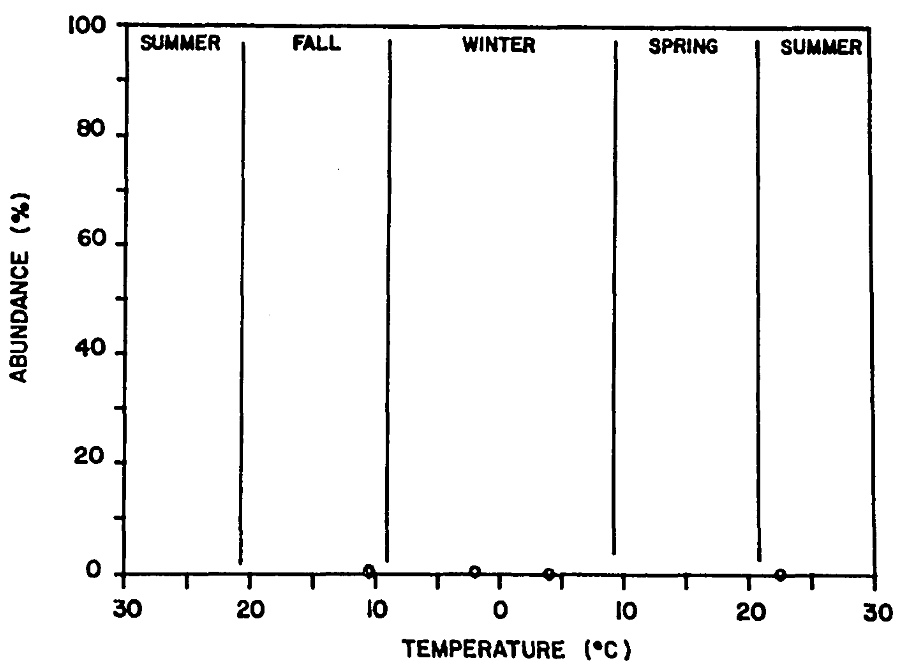

Figure 81. Abundance vs. temperature and season for populations of *Surirella iowensis*

periodicity or temperature preference (Figure 81).

<u>Surirella ovata</u> Kutz. var. <u>ovata</u>

<u>Plate</u>: 23, Fig. 11.

<u>Critical reference</u>: Hustedt, 1930a, p. 442, Figs. 863, 864.

<u>Descriptors</u>: Striae, 15 - 18 in 10 µm. Keel canals, 4 - 6 in 10 µm. Length, 20 - 50 µm. Breadth, 8 - 20 µm.

<u>Ecology</u>: Freshwater rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977); lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948; 1954, 1958, 1964; Hustedt, 1957; Cholnoky, 1968). Oligohalobous indifferent (Petersen, 1943; Foged, 1948, 1954; Hustedt, 1957). Mesosaprobic (Kolkwitz and Marsson, 1908; Schroeder, 1939; Foged 1948). Rheophilous (Foged, 1948, 1954; Scheele, 1952; Hornung, 1959). Oligothermal to eurythermal (Budde, 1931). Seasonal maximum - winter (Schroeder, 1939; Hornung, 1959).

<u>Previous reports from Iowa</u>: Lake West Okoboji (Stoermer, 1963a; Hosseini, 1979). Spirit Lake (Krohn et al., 1974). Coralville Reservoir (Schmidt and Fee, 1967). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969). Skunk River (Roeder, 1976). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Dutch Creek (Fee, 1967). Farm ponds (Ohl, 1965). Soil (Hayek and Hulbary, 1956; Loescher,

1971). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

<u>Occurrence</u>: Rare in a single spring plankton sample from Lake East Okoboji (Table 241). No clear indication of periodicity or temperature preference.

Table 241. Summary of distribution and relative abundance for *Surirella ovata* v. *ovata*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji		r									

Surirella ovata var. pinnata (Wm. Smith) Hust.

Plate: 23, Fig. 12.

Critical reference: Hustedt, 1930a, p. 442, Fig. 865.

Descriptors: Striae, 16 in 10 µm. Keel canals, 5 in 10 µm. Length, 31.5 µm. Breadth, 10.5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Stoermer and Yang, 1969).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Lake East Okoboji (Volker, 1963). Coralville Reservoir (Schmidt and Fee, 1967). Des Moines River (Drum, 1964). Dutch Creek (Fee, 1967). Skunk River (Roeder, 1976). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965). Subaerial habitats (Stoermer, 1962). Pillsbury and Sylvan lake beds (Hungerford, 1972). Spirit Lake (Krohn et al., 1974).

Occurrence: Rare in the plankton of the Lake District (Table 242).

Synedra acus Kutz. var. acus

Plate: 11, Fig. 1.

Critical reference: Patrick and Reimer, 1966, p. 135, Pl. 5, Fig. 1.

Descriptors: Striae, 11 - 14 in 10 µm. Length, 81 - 118 µm. Breadth, 3.5 - 5.5 µm.

Ecology: Freshwater lakes (Jorgensen, 1948; Stoermer

Table 242. Summary of distribution and relative abundance for <u>Surirella</u> <u>ovata</u> var. <u>pinnata</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake									r		
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji											

Table 243. Summary of distribution and relative abundance for <u>Synedra</u> <u>acus</u> v. <u>acus</u>

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake	r	o	r	r	r					r	
West Okoboji		r			r		r		r		
Center Lake											
Spirit Lake	r	r	r				r	r			r
East Okoboji	r	r	r			r		r		r	r

and Yang, 1969); rivers (Collins and Kalinsky, 1977). Periphytic (Hustedt, 1937 - 1938; Schroeder, 1939; Manguin, 1952); tychoplanktonic (Schroeder, 1939; Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1954, 1958, 1968; Jorgensen, 1948; Hustedt, 1957; Cholnoky, 1968). Eutrophic (Jorgensen, 1948). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Manguin, 1952). Oligosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914; Hustedt, 1957). Limnophilous (Foged, 1948, 1954). Seasonal maximum - spring (Schroeder, 1939); summer (Blum, 1957).

Previous reports from Iowa: Clear Lake (Begres, 1971). North Twin Lake (Kutkukn, 1958). Lake West Okoboji (Stoermer, 1963a; Hostetter and Stoermer, 1968; Hosseini, 1979). Lake East Okoboji (Volker, 1963). Pillsbury and Sylvan lake beds (Hungerford, 1972). Des Moines River (Starrett and Patrick, 1952; Gudmundson, 1969). Skunk River (Beckert, 1977). Coralville Reservoir (Schmidt and Fee, 1967). Spirit Lake (Krohn et al., 1974). Drainage ditches (Lowe, 1970).

Occurrence: Observed in plankton samples from all of the lakes except Center Lake (Table 243). Perennial species occurring at temperatures from 0°- 25°C (Figure 82). No clear indication of temperature preference. More common than the nominate variety.

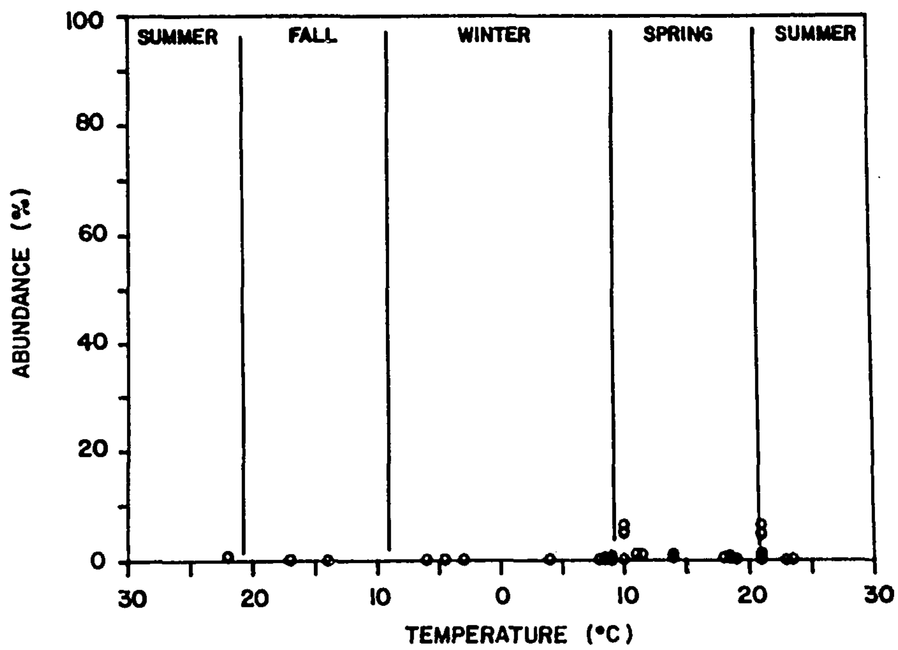

Figure 82. Abundance vs. temperature and season for populations of *Synedra acus*

Table 244. Summary of distribution and relative abundance for *Synedra cyclopum* v. *cyclopum*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji				o	r					r	r
Center Lake											
Spirit Lake		c	o	r		r		o	r	r	a
East Okoboji									o	o	c

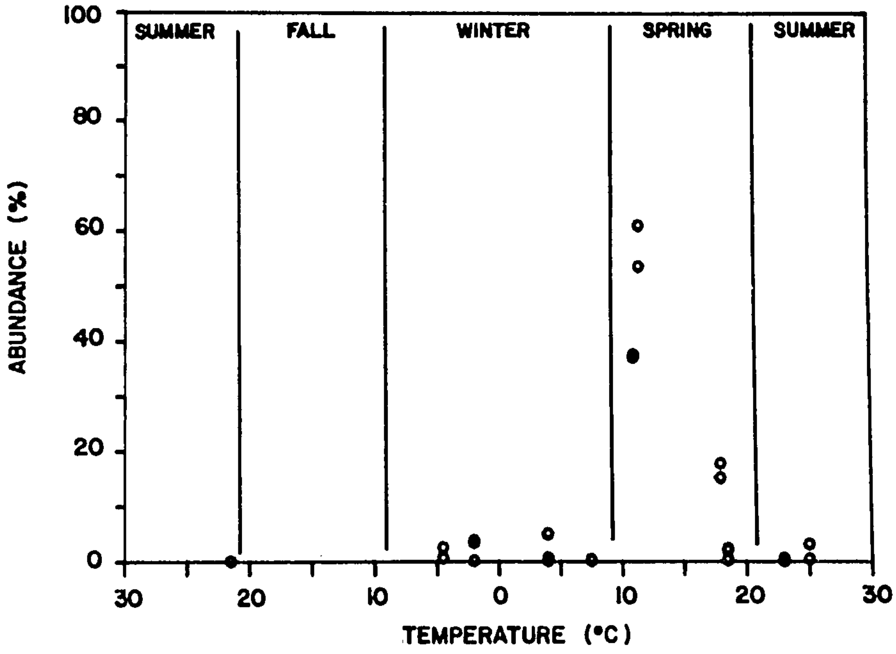

Figure 83. Abundance vs. temperature and season for populations of <u>Synedra cyclopum</u>

Table 245. Summary of distribution and relative abundance for <u>Synedra cyclopum</u> v. <u>robustum</u>

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			r								
East Okoboji			r								

Synedra cyclopum Brutschy var. *cyclopum*

Plate: 10, Fig. 8 and 9.

Critical reference: Patrick and Reimer, 1966, p. 155, Pl. 8, Figs. 6 - 7.

Descriptors: Striae, 15 in 10 µm. Length, 24 - 26 µm. Breadth, 4 - 5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969). Often attached to Crustacea (epizoic), in cool water (Patrick and Reimer, 1966).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Spirit Lake (Krohn et al., 1974).

Occurrence: Observed in plankton samples from Lake West Okoboji, Spirit Lake and Lake East Okoboji (Table 244). Occurs at temperatures from 0°- 25°C, but most abundant at 10° C during the early spring turnover (Figure 83).

Synedra cyclopum var. *robustum* Schulz

Plate: 10, Fig. 11.

Critical reference: Patrick and Reimer, 1966, p. 155, Pl. 8, Fig. 8.

Descriptors: Striae, 16 - 18 in 10 µm. Length, 29 µm. Breadth, 5.2 µm.

Ecology: Freshwater alkaliphilous (Patrick and Reimer, 1966).

Previous reports from Iowa: None.

Occurrence: Less frequently encountered than the nominate variety (Table 245). Rare in the spring plankton of Spirit Lake and Lake East Okoboji. No clear indication of periodicity or temperature preference.

Synedra delicatissima var. *angustissima* Grun.

Plate: 10, Fig. 14.

Critical reference: Patrick and Reimer, 1966, p. 136, Pl. 5, Fig. 2.

Descriptors: Striae, 14 in 10 µm. Length, 130 µm. Breadth, 4.5 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977). Euplanktonic (Hustedt, 1957; Patrick and Reimer, 1966; Stoermer and Yang, 1969). pH indifferent (Foged, 1948, 1949, 1954). Eutrophic (Hustedt, 1957). Oligohalobous indifferent (Petersen, 1943; Foged, 1948, 1954, 1968). Limnophilous (Foged, 1948, 1954).

Previous reports from Iowa: None.

Occurrence: Rare in the plankton of Lake West Okoboji and Spirit Lake (Table 246). No clear indication of periodicity or temperature preference (Figure 84). Occurred at temperatures between 5°- 25°C.

Table 246. Summary of distribution and relative abundance for *Synedra delicatissima* v. *angustissima*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					o	r					
Center Lake											
Spirit Lake		r									
East Okoboji											

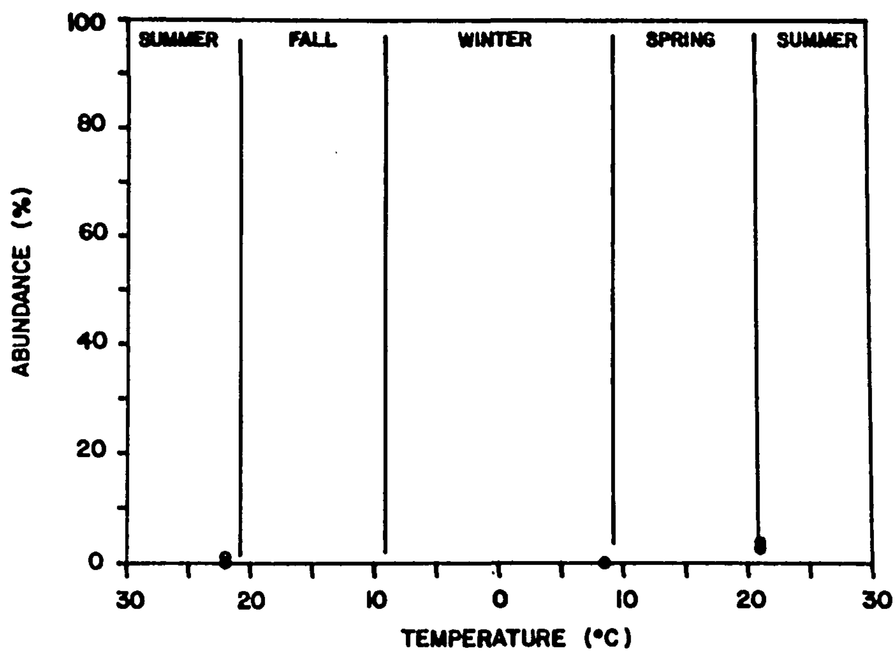

Figure 84. Abundance vs. temperature and season for populations of *Synedra delicatissima* v. *angustissima*

<u>Synedra filiformis</u> Grun. var. <u>filiformis</u>

<u>Plate</u>: 11, Fig. 8.

<u>Critical reference</u>: Stoermer and Yang, 1969, p. 189.

<u>Descriptors</u>: Striae, 25 - 30 in 10 µm. Length, 58.5 - 77.5 µm. Breadth, 2 - 2.2 µm.

<u>Ecology</u>: Freshwater lakes (Stoermer and Yang, 1969). Euplanktonic (Stoermer and Yang, 1969).

<u>Previous reports from Iowa</u>: None.

<u>Occurrence</u>: Not uncommon in the spring plankton of Center Lake and Spirit Lake; rare in lakes East and West Okoboji (Table 247). Seems to prefer temperatures between 5° - 20°C (Figure 85).

<u>Synedra parasitica</u> (Wm. Smith) Hust. var. <u>parasitica</u>

<u>Plate</u>: 10, Fig. 13.

<u>Critical</u>: Patrick and Reimer, 1966, p. 140, Pl. 5, Fig. 12

<u>Descriptors</u>: Striae, 17 - 19 in 10 µm. Length, 14 - 16 µm. Breadth, 5.4 µm.

<u>Ecology</u>: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Usually epiphytic on other diatoms, in circumneutral, slightly alkaline water (Patrick and Reimer, 1966). Mesotrophic to eutrophic (Patrick and Reimer, 1966).

<u>Previous reports from Iowa</u>: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968).

Table 247. Summary of distribution and relative abundance for *Synedra filiformis* v. *filiformis*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji					r						
Center Lake		c									
Spirit Lake	r	c	o	r							
East Okoboji		r									

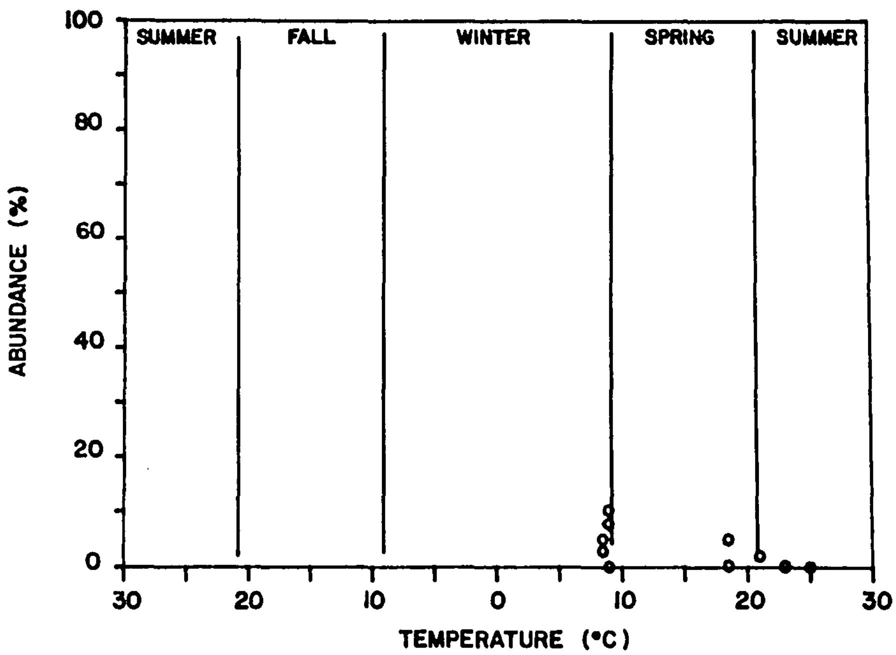

Figure 85. Abundance vs. temperature and season for populations of *Synedra filiformis*

Table 248. Summary of distribution and relative abundance for _Synedra parasitica_ v. _parasitica_

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake											
East Okoboji			r	r				r			

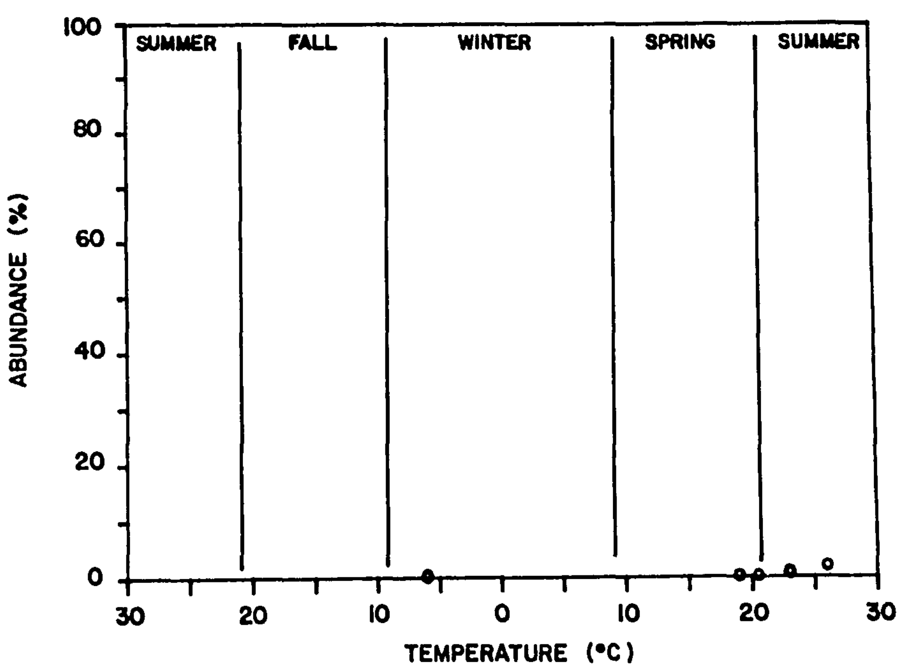

Figure 86. Abundance vs. temperature and season for populations of _Synedra parasitica_

Lake East Okoboji (Volker, 1963). Des Moines River (Drum, 1964). Skunk River (Roeder, 1976). Pillsbury and Sylvan Lake beds (Hungerford, 1972).

Occurrence: Rare in the plankton of Lake East Okoboji (Table 248). No clear indication of periodicity or temperature preference (Figure 86).

Synedra rumpens var. *familiaris* (Kutz.) Hust.

Plate: 11, Fig. 3.

Critical reference: Patrick and Reimer, 1966, p. 143, Pl. 5, Fig. 20.

Descriptors: Striae, 15 - 18 in 10 µm. Length, 40 - 50 µm. Breadth, 3 - 3.2 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Periphytic (Manguin, 1952); euplanktonic (Stoermer and Yang, 1969). pH indifferent (Patrick and Reimer, 1966). Oligohalobous (Kolbe, 1927; Manguin, 1952).

Previous reports from Iowa: Lake West Okoboji (Stoermer, 1963a). Des Moines River (Drum, 1964). Farm ponds (Ohl, 1965). Clear Lake (Begres, 1971).

Occurrence: Rare in the plankton of Spirit Lake (Table 249). No clear indication of periodicity or optimum temperature for growth.

Table 249. Summary of distribution and relative abundance for *Synedra rumpens* v. *familiaris*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake		r	r								
East Okoboji											

Synedra rumpens var. fragilarioides Grun.

Plate: 11, Fig. 2.

Critical reference: Patrick and Reimer, 1966, p. 144, Pl. 6, Fig. 1.

Descriptors: Striae, 9 - 13 in 10 µm. Length, 44 - 76 µm. Breadth, 3 - 4 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Collins and Kalinsky, 1977); springs (Patrick and Reimer, 1966). Periphytic (Hustedt, 1949; euplanktonic (Stoermer and Yang, 1969). pH indifferent (Patrick and Reimer, 1966).

Previous reports from Iowa: Clear Lake (Begres, 1971). Lake West Okoboji (Stoermer, 1963a; Collins, 1968). Drainage ditches (Lowe, 1970; Edwards, 1974).

Occurrence: Rare in the plankton of all the lakes (Table 250). Perennial species, occurring at temperatures from 5°- 25°C (Figure 87). No clear indication of periodicity.

Synedra rumpens var. scotica Grun.

Plate: 11, Fig. 4.

Critical reference: Patrick and Reimer, 1966, p. 144, Pl. 6, Fig. 2.

Descriptors: Striae, 15 - 16 in 10 µm. Length, 47 - 49 µm. Breadth, 2 - 3 µm.

Ecology: Freshwater rivers (Hohn and Hellerman, 1963;

Table 250. Summary of distribution and relative abundance for *Synedra rumpens* var. *fragilarioides*

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake			r				r				
West Okoboji				r							r
Center Lake				r							
Spirit Lake			r	r							
East Okoboji			r			r		r			

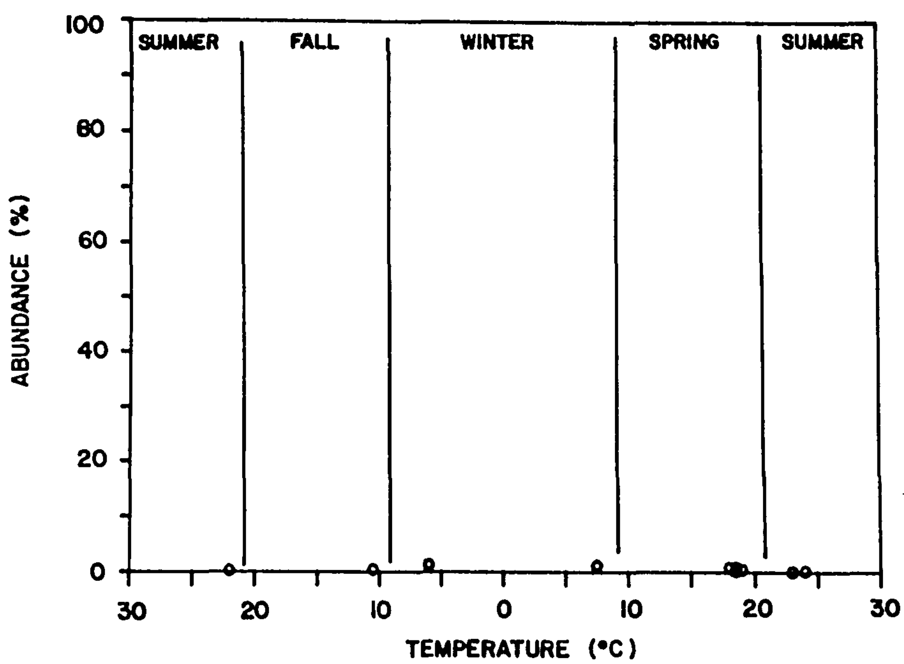

Figure 87. Abundance vs. temperature and season for populations of *Synedra rumpens* v. *fragilarioides*

Table 251. Summary of distribution and relative abundance for *Synedra rumpens* v. *scotica*

				1979						1980	
Lake	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Jan	Mar	Apr
Silver Lake											
West Okoboji											
Center Lake											
Spirit Lake			o								
East Okoboji											

Collins and Kalinsky, 1977). pH indifferent (Foged, 1948; Patrick and Reimer, 1966).

Previous reports from Iowa: None.

Occurrence: A rare form in the plankton of the Lake District (Table 251). Observed in spring samples from Spirit Lake. No clear indication of periodicity or temperature preference.

Synedra socia Wallace var. *socia*

Plate: 10, Fig. 12.

Critical reference: Patrick and Reimer, 1966, p. 145, Pl. 6, Figs. 4 - 6.

Descriptors: Striae, 16 - 17 in 10 µm. Length, 15 - 25 µm. Breadth, 3 - 4 µm.

Ecology: Freshwater rivers (Collins and Kalinsky, 1977). Found in circumneutral water (ph indifferent) of low conductivity (Patrick and Reimer, 1966).

Previous reports from Iowa: None.

Occurrence: Rare in a single winter plankton sample from Lake West Okoboji (Table 252). No clear indication of periodicity or optimum temperature for occurrence.

Synedra ulna (Nitz.) Ehr. var. *ulna*

Plate: 11, Fig. 9.

Critical reference: Patrick and Reimer, 1966, p. 148, Pl. 7, Figs. 1 and 2.

Descriptors: Striae, 9 - 13 in 10 µm. Length, 54 -

Table 252. Summary of distribution and relative abundance for Synedra socia v. socia

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake											
West Okoboji										r	
Center Lake											
Spirit Lake											
East Okoboji											

Table 253. Summary of distribution and relative abundance for Synedra ulna v. ulna

Lake	Apr	May	Jun	1979 Jul	Aug	Sep	Oct	Nov	Jan	1980 Mar	Apr
Silver Lake	r	r	r	r				r	r		
West Okoboji		r	r		r			r			
Center Lake	r	r		r							
Spirit Lake		r	r	r					r		
East Okoboji			r					r			

315 µm. Breadth, 3.5 - 7 µm.

Ecology: Freshwater lakes (Stoermer and Yang, 1969); rivers (Hohn and Hellerman, 1963; Collins and Kalinsky, 1977). Euplanktonic (Manguin, 1952; Stoermer and Yang, 1969). Alkaliphilous (Foged, 1948, 1954, 1964, 1968a; Scheele, 1952; Hustedt, 1957; Merilainen, 1967). Eutrophic (Hustedt, 1937 - 1938; 1957). Oligohalobous indifferent (Foged, 1948, 1954, 1968a; Hustedt, 1957). Oligosaprobic (Kolkwitz and Marsson, 1908; Kolkwitz, 1914; Fjerdingstadt, 1950; Blum, 1957) to beta - mesosaprobic (Kolkwitz, 1914; Hustedt, 1937 - 1938; 1957; Fjerdingstadt, 1950). Current indifferent (Foged, 1948, 1954; Scheele, 1952). Eurythermal and oligothermal to mesothermal (Scheele, 1952). Seasonal maximum - spring (Raabe, 1951); summer (Blum, 1957); fall (Schroeder, 1939; Raabe, 1951).

Previoius reports from Iowa: Lake West Okoboji (Stoermer, 1963a; Collins, 1968; Hosseini, 1979). North Twin Lake (Kutkukn, 1958). Lake East Okoboji (Volker, 1963). Spirit Lake (Krohn et al., 1974). Clear Lake (Begres, 1971). Arend's Kettle Hole (Collins, 1968). Des Moines River (Starrett and Patrick, 1952; Drum, 1964; Gudmundson, 1969) Skunk River (Beckert, 1977). Dutch Creek (Fee, 1967). Brewer's Creek (Edwards and Christensen, 1973). Drainage ditches (Lowe, 1970; Edwards, 1974). Farm ponds (Ohl, 1965).

Occurrence: Frequently encountered in plankton samples from all the lakes, but always rare (Table 253).

Perennial species, occurring at temperatures from 0° - 25°C (Figure 88). No clear indication of temperature preference.

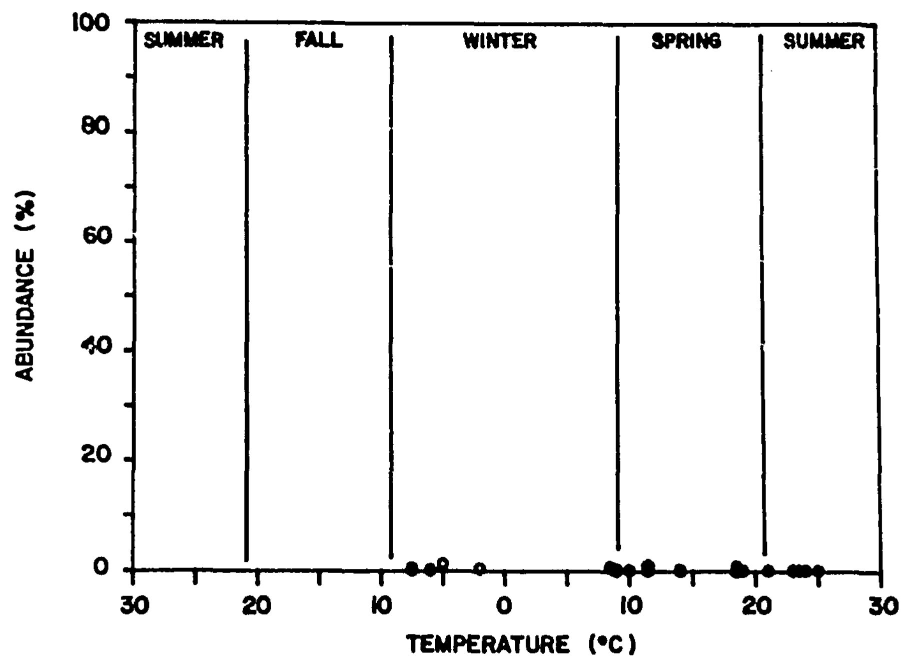

Figure 88. Abundance vs. temperature and season for populations of _Synedra ulna_

Plate 1

Fig. 1.	*Melosira islandica* var. *islandica*, x1250.
Fig. 2.	*Melosira italica* var. *italica*, x1250.
Fig. 3.	*Melosira granulata* var. *granulata*, x1250.
Fig. 4.	*Melosira varians* var. *varians*, x1250.
Fig. 5.	*Melosira granulata* var. *granulata*, x1250.
Fig. 6.	*Melosira granulata* var. *angustissima*, x1250.
Fig. 7.	*Melosira ambigua* var. *ambigua*, x1250.
Fig. 8.	*Cyclotella bodanica* var. *bodanica*, x1250.
Fig. 9-10.	*Cyclotella michiganiana* var. *michiganiana*, x1250.
Fig. 11.	*Cyclotella striata* var. *striata*, x1250.
Fig. 12.	*Cyclotella compta* var. *compta*, x1250.
Fig. 13.	*Cyclotella striata* var. *striata*, x1250.
Fig. 14.	*Cyclotella stelligera* var. *stelligera*, x1250.

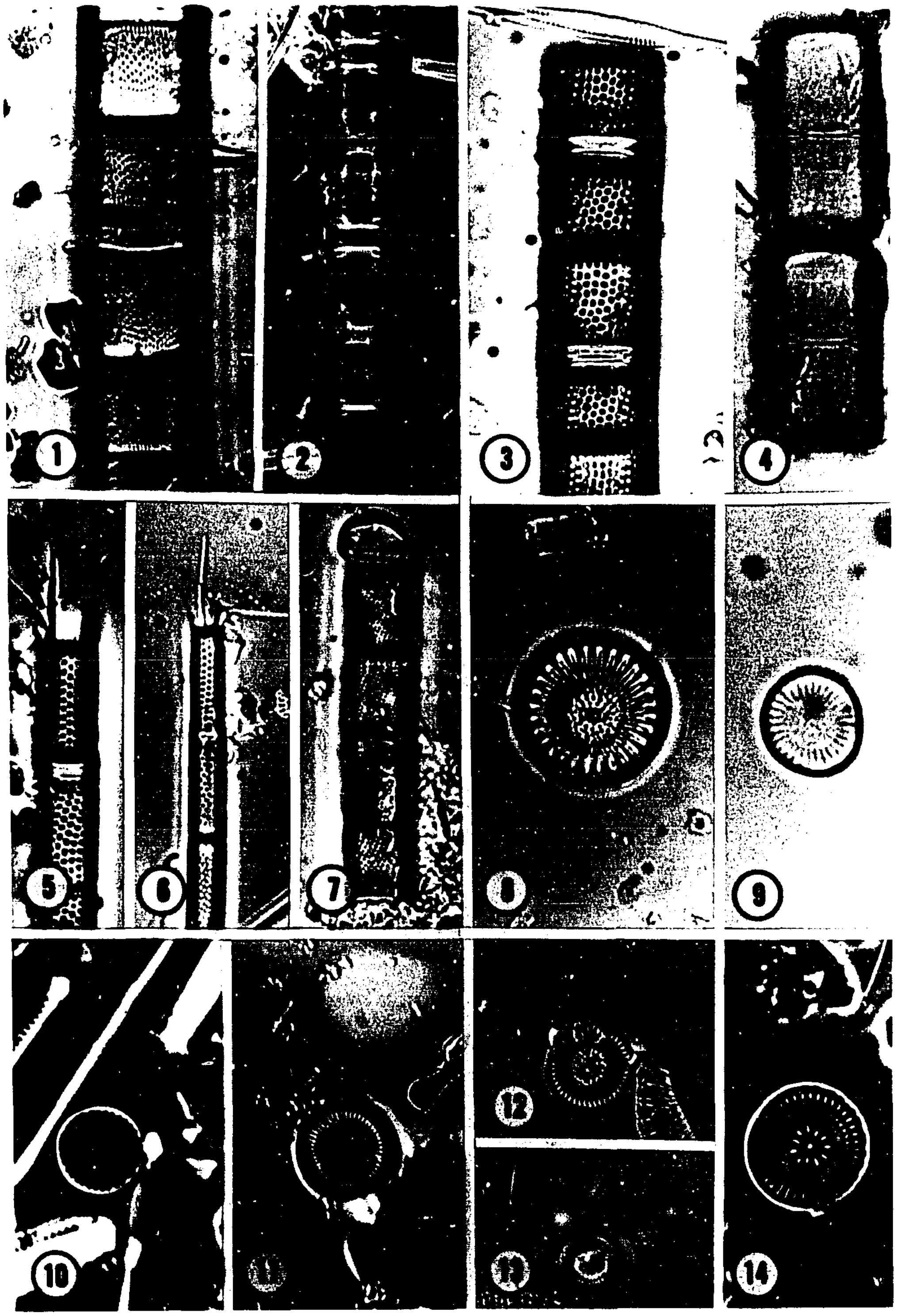
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Plate 2

Fig. 1. *Cyclotella meneghiniana* var. *meneghiniana*, TEM carbon replica, x5972.

Fig. 2. *Cyclotella meneghiniana* var. *meneghiniana*, TEM carbon replica, valve face, x51,840.

Fig. 3. *Cyclotella meneghiniana* var. *meneghiniana*, TEM carbon replica, inside of valve, x5972.

Fig. 4. *Cyclotella meneghiniana* var. *meneghiniana*, TEM carbon replica, girdle view of valve, x5972.

Fig. 5. *Cyclotella meneghiniana* var. *meneghiniana*, x1250.

Fig. 6. *Stephanodiscus minutus* var. *minutus*, phase contrast microscopy, x2500.

Fig. 7. *Stephanodiscus minutus* var. *minutus*, x2500.

Fig. 8. *Stephanodiscus minutus* var. *minutus*, x1250.

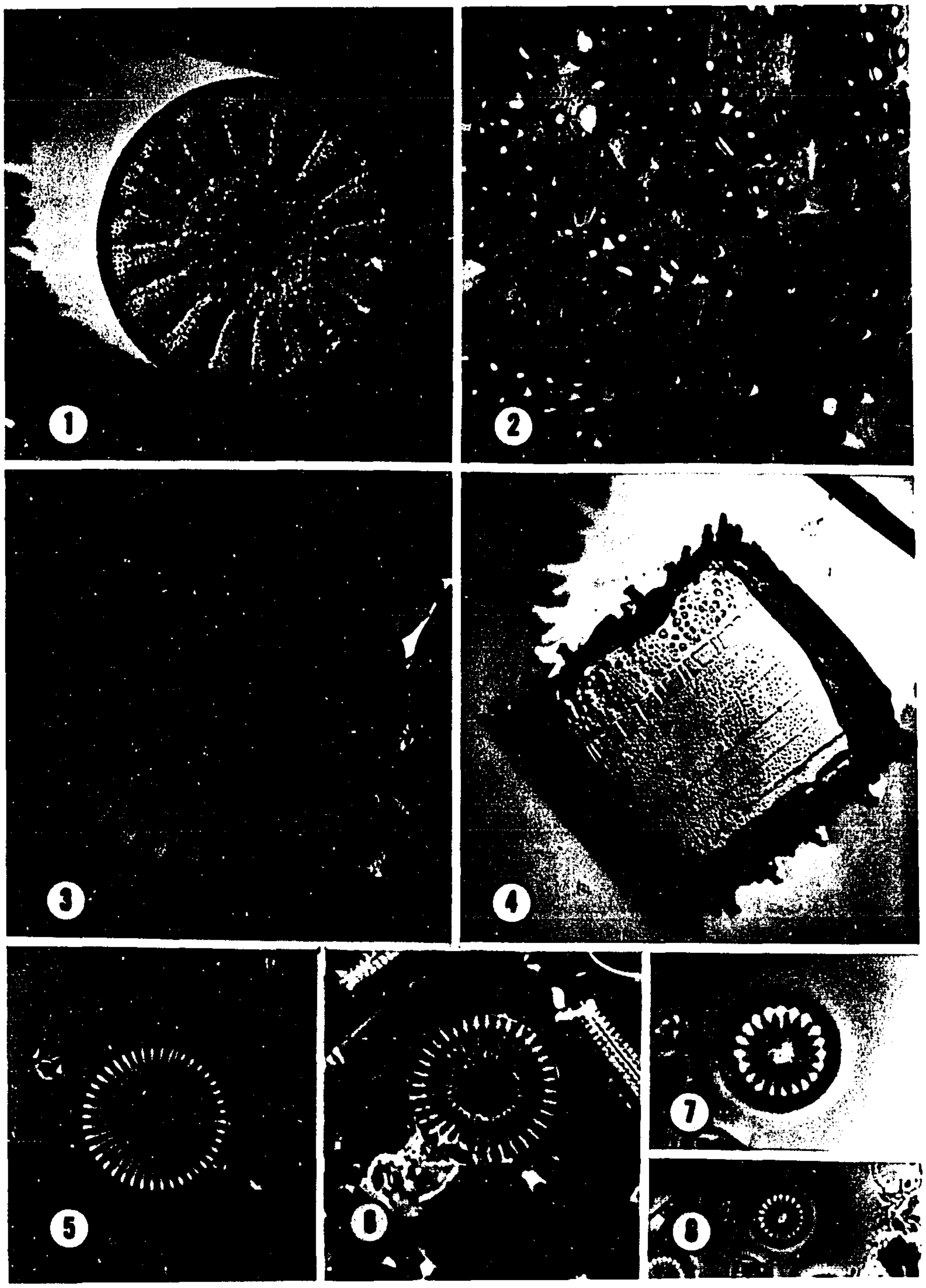
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Plate 3

Fig. 1-2. Stephanodiscus niagarae var. magnifica, x1250.
Fig. 3-4. Stephanodiscus niagarae var. niagarae, x1250.
Fig. 5-6. Stephanodiscus tenuis var. tenuis, x1250 and x2500, respectively.
Fig. 7-8. Stephanodiscus tenuis var. tenuis, x1250 and x2500, respectively.
Fig. 9a-d. Stephanodiscus tenuis var. tenuis, 9a. Stephanodiscus hantzschii var. hantzschii, 9b-d. Phase contrast microscopy, x1250.
Fig. 10. Stephanodiscus tenuis var. tenuis, phase contrast microscopy, x1250.
Fig. 11-12. Stephanodiscus hantzschii var. hantzschii, x1250 and x2500, respectively.
Fig. 13-14. Stephanodiscus tenuis var. tenuis, x1250 and x2500, respectively.

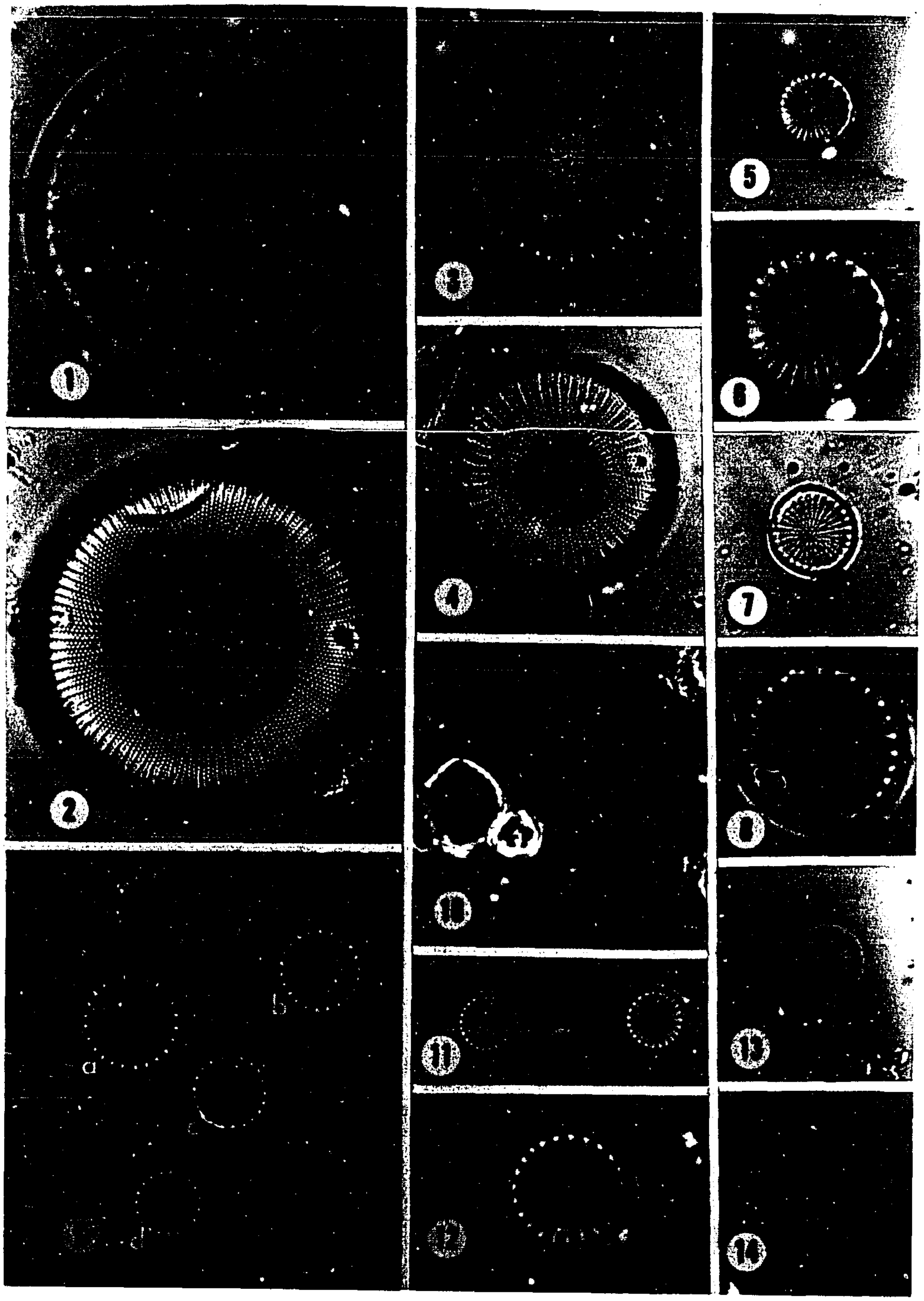
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Plate 4

Fig. 1-4. <u>Stephanodiscus</u> <u>niagarae</u> var. <u>niagarae</u>, valve face. Fig. 1. SEM micrograph (25kv, tilt = 0°), x2000. Fig. 2. SEM micrograph (25kv, tilt = 45°), x2400. Fig. 3. SEM micrograph (25kv, tilt = 0°), x2400. Fig. 4. SEM (25kv, tilt = 0°), x8600.

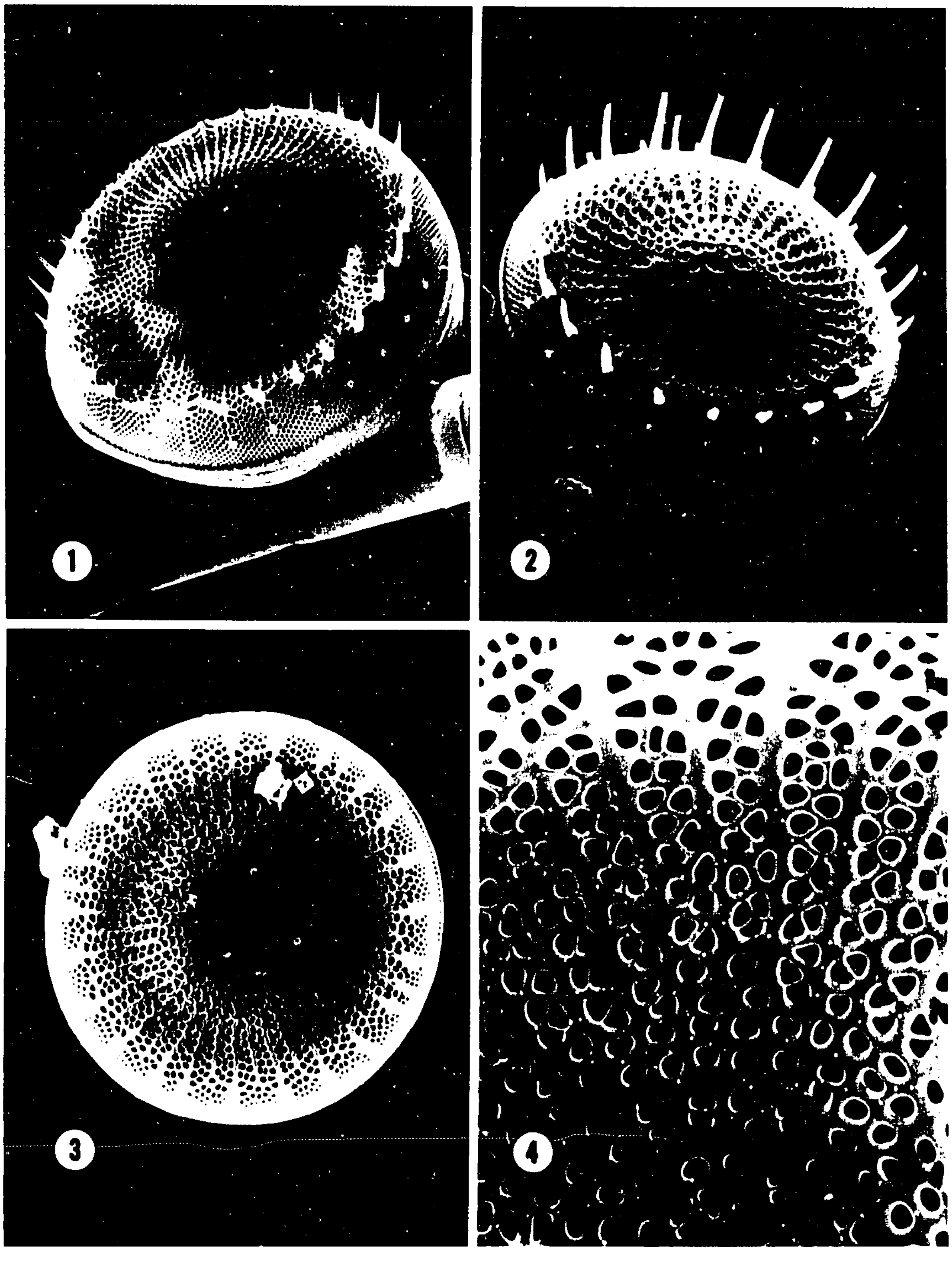

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Plate 5

Fig. 1-2. Stephanodiscus niagarae var. niagarae, inside of valve. Fig. 1. SEM micrograph (25kv, tilt = 50°), x2000. Fig. 2. SEM micrograph (25kv, tilt = 0°), x8600.

Fig. 3-4. Stephanodiscus niagarae var. magnifica, valve face. Fig. 3. SEM (25kv, tilt = 0°), x860. Fig. 4. SEM (25kv, tilt = 45°), x2000.

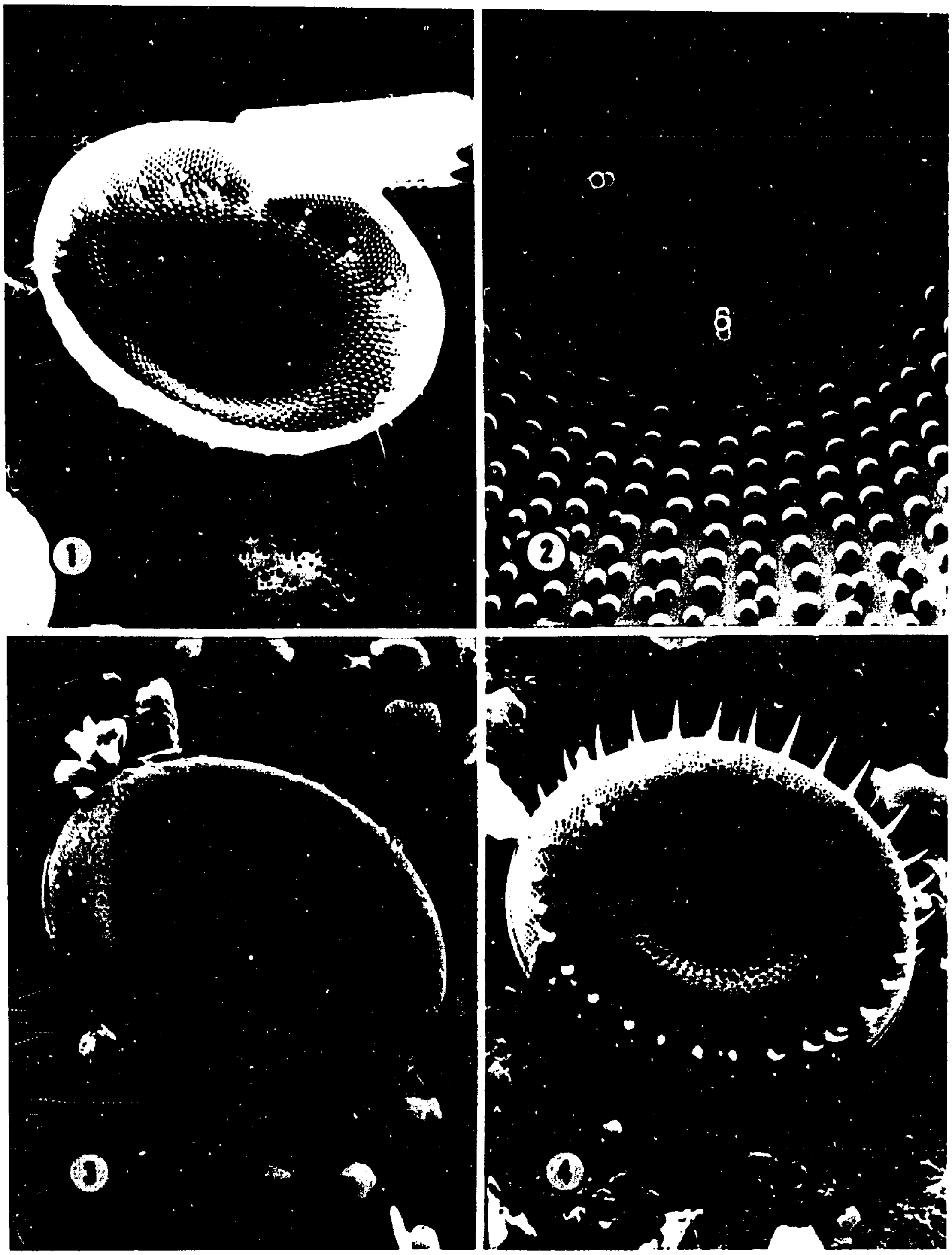

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Plate 6

Fig. 1-2. *Stephanodiscus niagarae* var. *magnifica*, valve face. Fig. 1. SEM (25kv, tilt = 0°), x1000. Fig. 2. SEM (25kv, tilt = 0°), x6600.

Fig. 3-4. *Stephanodiscus niagarae* var. *magnifica*, inside of valve. Fig. 3. SEM (25kv, tilt = 50°), x1200. Fig. 4. SEM (25kv, tilt = 50°), x8600.

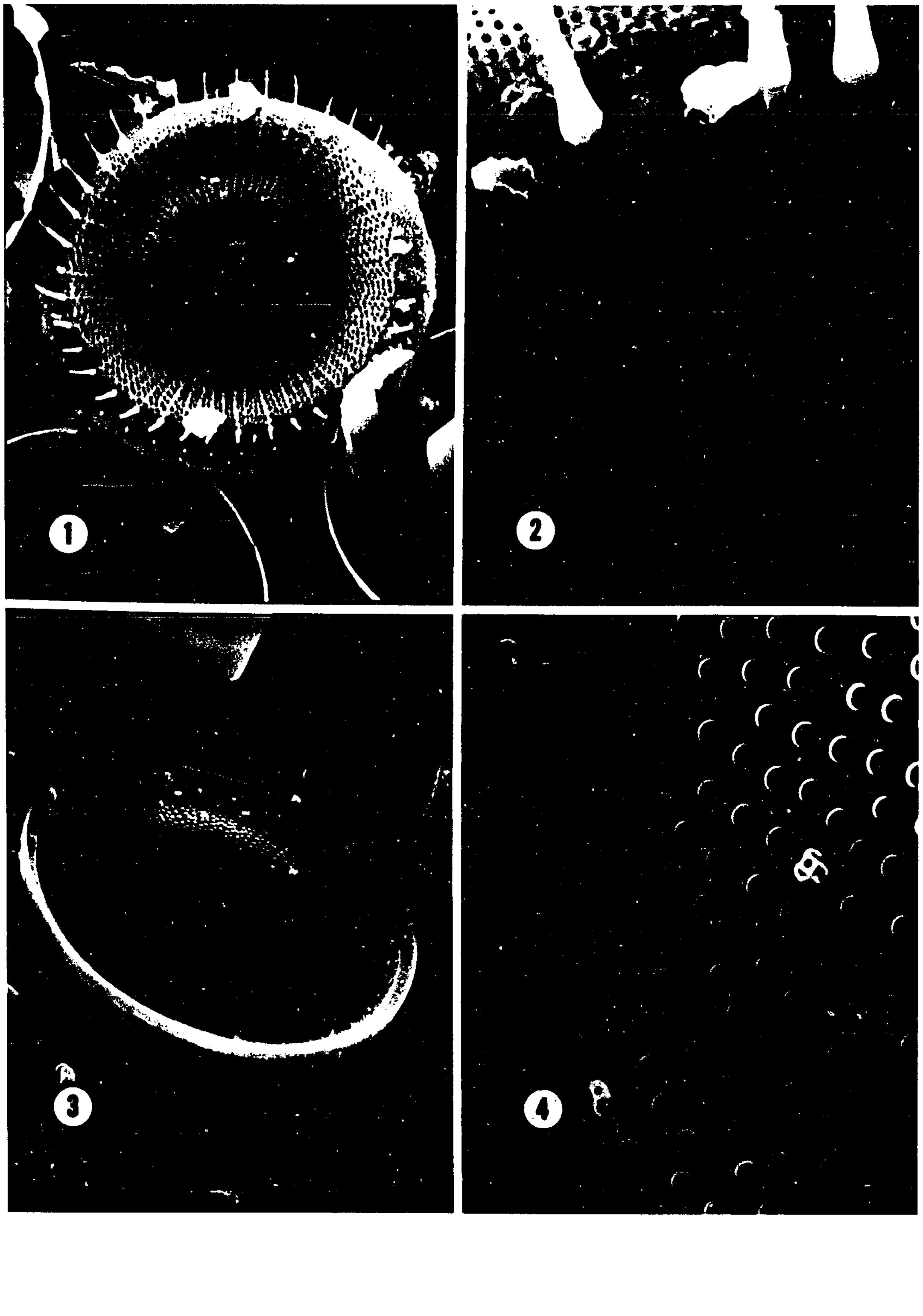
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Plate 7

Fig. 1-4.	Stephanodiscus tenuis var. tenuis. Fig. 1. SEM (25kv, tilt = 45°), x4000. Fig. 2-4. TEM carbon replicas, x4406.
Fig. 5-6.	Stephanodiscus hantzschii var. hantzschii, SEM (25kv, tilt =50°), x5400 and x6000, respectively.

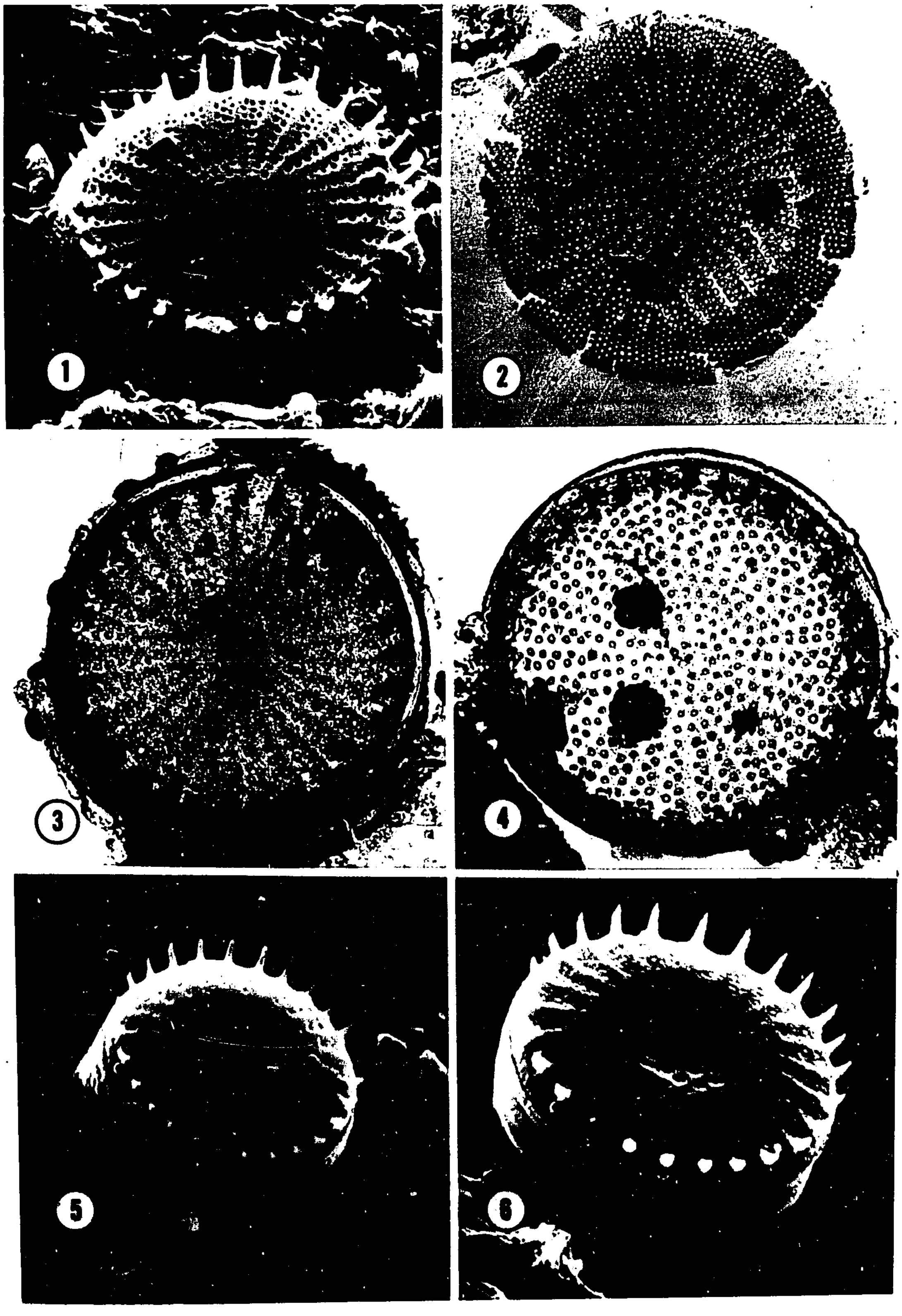
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Plate 8

Fig. 1-3,5. _Stephanodiscus_ _hantzschii_ var. _hantzschii_. Fig. 1-2. SEM (25kv, tilt = 25° and 60°, repectively), x6600. Fig. 3 and 5. TEM carbon replicas, x8003 and x5972, respectively.

Fig. 4. _Stephanodiscus_ _tenuis_ var. _tenuis_, TEM carbon replica, x5972.

Fig. 6. _Stephanodiscus_ _minutus_ var. _minutus_, TEM carbon replica, x5972.

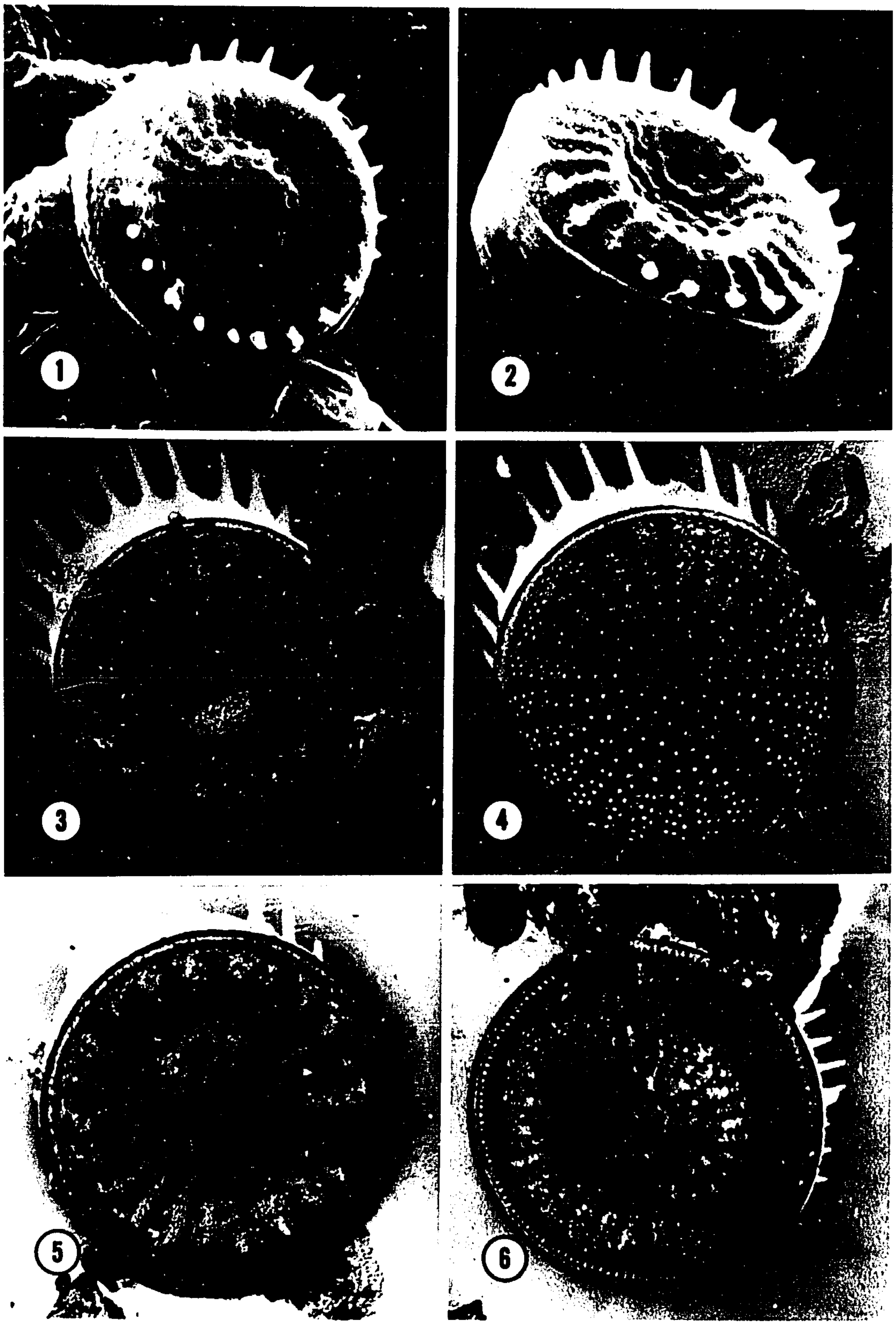
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Plate 9

Fig. 1. *Meridion circulare* var. *circulare*, x1250.
Fig. 2. *Meridion circulare* var. *constricta*, x1250.
Fig. 3. *Diatoma vulgare* var. *vulgare*, x1250.
Fig. 4-5. *Asterionella formosa* var. *formosa*, x1250 and x500, respectively.
Fig. 6. *Fragilaria brevistriata* var. *inflata*, x1250.
Fig. 7. *Fragilaria brevistriata* var. *capitata*, x1250.
Fig. 8. *Fragilaria brevistriata* var. *brevistriata*, x1250.
Fig. 9. *Fragilaria capucina* var. *capucina*, x1250.
Fig. 10. *Fragilaria capucina* var. *mesolepta*, x1250.
Fig. 11. *Fragilaria crotonensis* var. *crotonensis*, x1250.
Fig. 12. *Fragilaria construens* var. *construens*, x1250.
Fig. 13. *Fragilaria construens* var. *binodis*, x1250.
Fig. 14. *Fragilaria construens* var. *venter*, x1250.
Fig. 15-16. *Fragilaria lapponica* var. *lapponica*, x1250.

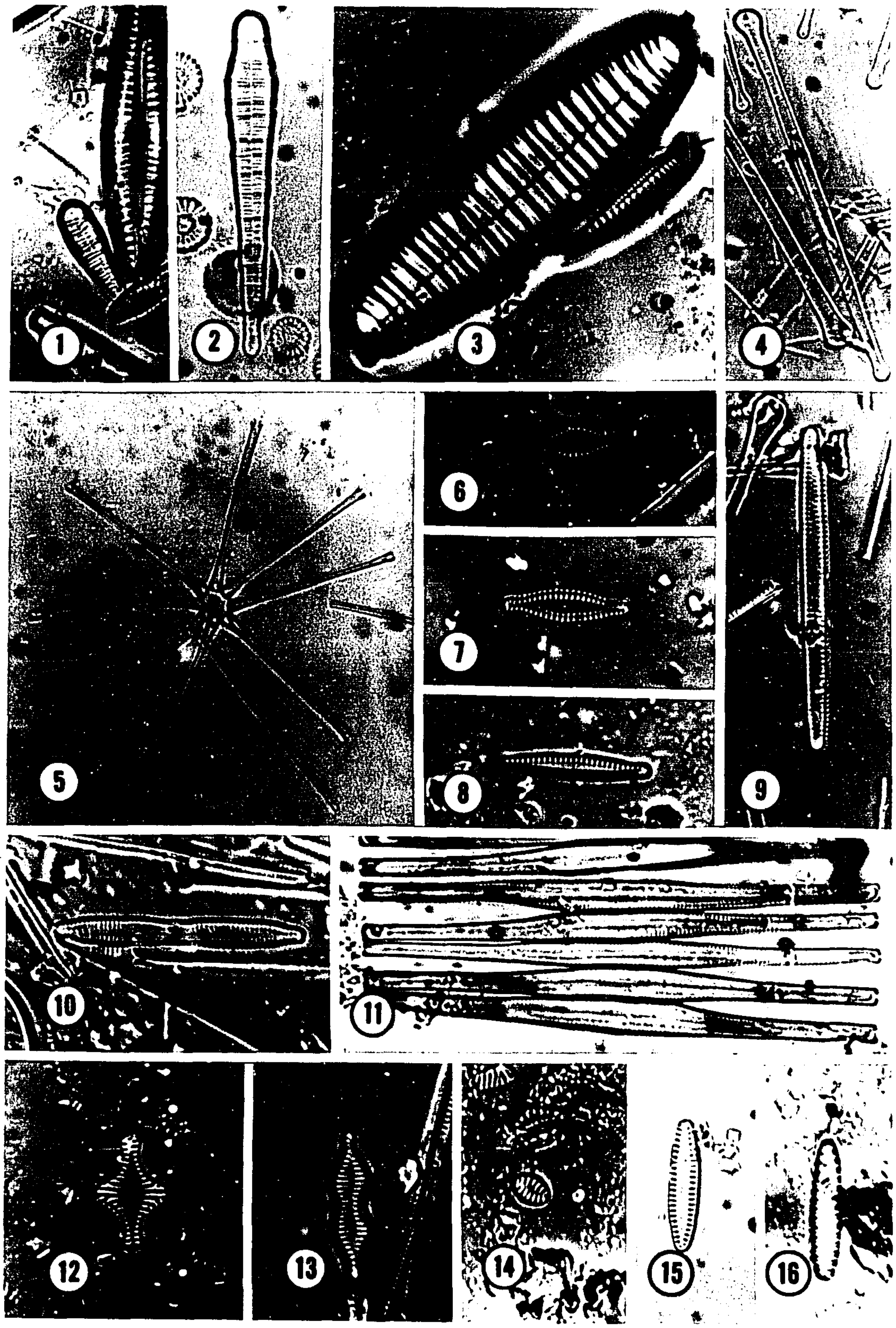
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Plate 10

Fig. 1. *Fragilaria crotonensis* var. *oregona*, x1250.
Fig. 2. *Fragilaria crotonensis* var. *crotonensis*, x1250.
Fig. 3,7. *Opephora martyi* var. *martyi*, x1250.
Fig. 4. *Fragilaria pinnata* var. *pinnata*, x1250.
Fig. 5. *Fragilaria virescens* var. *virescens*, x1250.
Fig. 6. *Fragilaria vaucheriae* var. *vaucheriae*, x1250.
Fig. 8-9. *Synedra cyclopum* var. *cyclopum*, x1250.
Fig. 10. *Fragilaria vaucheriae* var. *vaucheriae*, x1250.
Fig. 11. *Synedra cyclopum* var. *robustii*, x1250.
Fig. 12. *Synedra socia* var. *socia*, x1250.
Fig. 13. *Synedra parasitica* var. *parasitica*, x1250.
Fig. 14. *Synedra delicatissima* var. *angustissima*, x500.

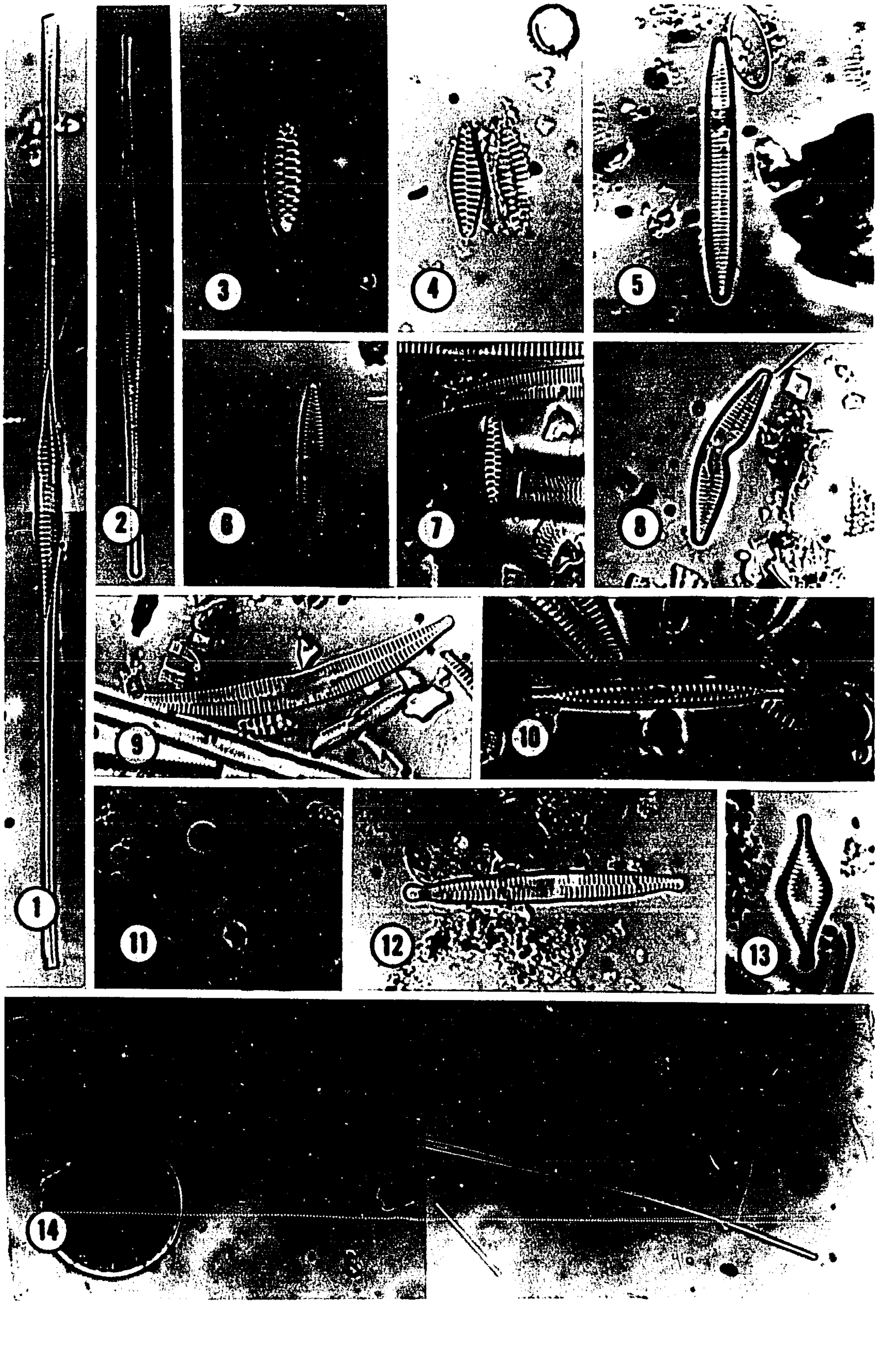
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Plate 11

Fig. 1.	*Synedra acus* var. *acus*, x1250.
Fig. 2.	*Synedra rumpens* var. *fragilarioides*, x1250.
Fig. 3.	*Synedra rumpens* var. *familiaris*, x1250.
Fig. 4.	*Synedra rumpens* var. *scotica*, x1250.
Fig. 5.	*Achnanthes affinis* var. *affinis*, x1250.
Fig. 6-7.	*Achnanthes clevei* var. *clevei*, raphe valve x1250.
Fig. 8.	*Synedra filiformis* var. *filiformis*, x1250.
Fig. 9.	*Synedra ulna* var. *ulna*, x1250.
Fig. 10.	*Eunotia glacialis* var. *glacialis*, x1250.
Fig. 11.	*Eunotia curvata* var. *curvata*, x1250.
Fig. 12.	*Achnanthes clevei* var. *clevei*, pseudoraphe valve x1250.
Fig. 13.	*Achnanthes clevei* var. *rostrata*, pseudoraphe valve x1250.
Fig. 14-15.	*Achnanthes conspicua* var. *conspicua*, raphe valve and pseudoraphe valve, respectively, x1250.
Fig. 16.	*Achnanthes exigua* var. *heterovalva*, x1250.

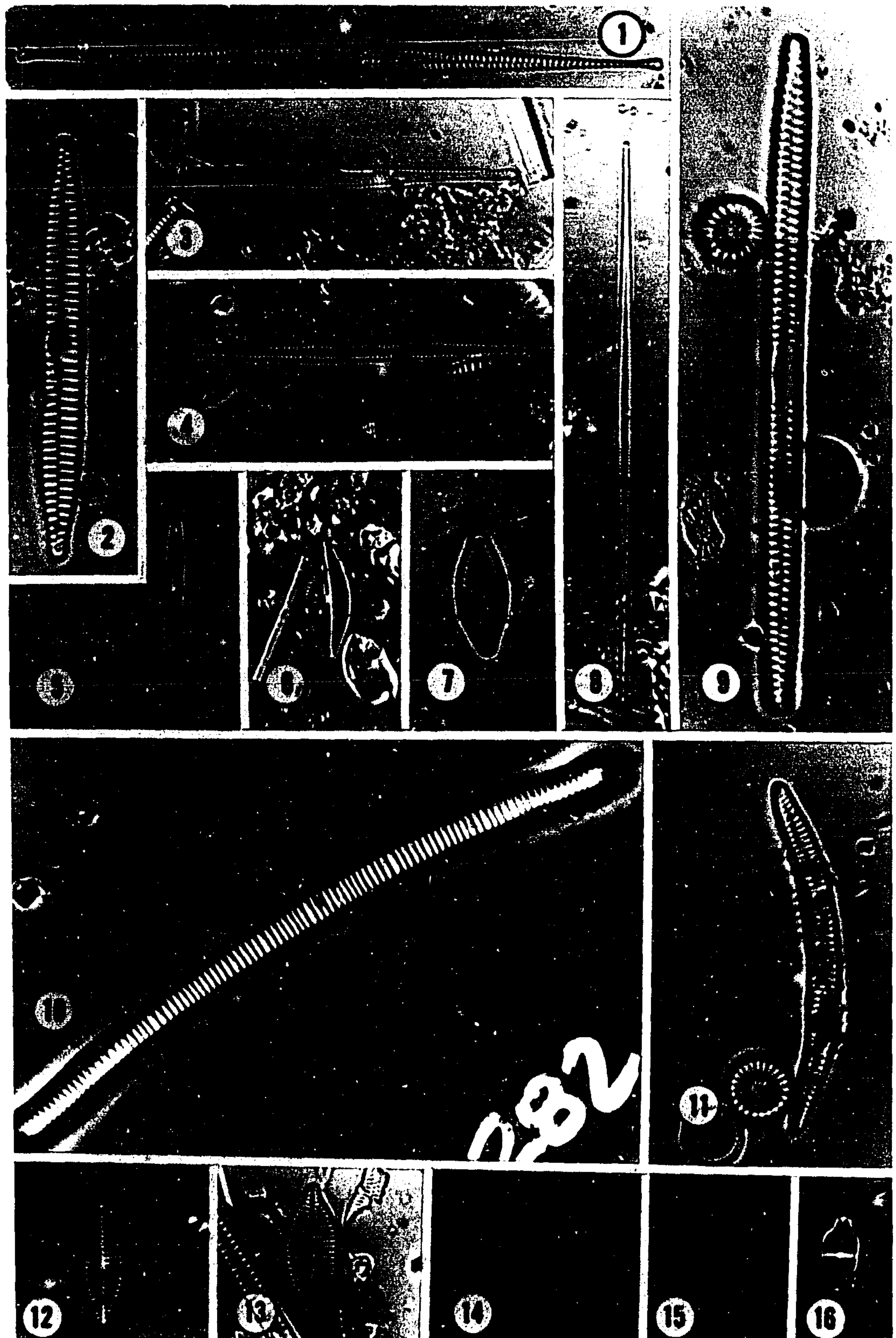

Plate 12

Fig. 1-2. *Achnanthes haukiana* var. *haukiana*, x1250. Raphe and pseudoraphe valve, respectively.
Fig. 3-4. *Achnanthes haukiana* var. *rostrata*, x1250. Raphe and pseudoraphe valve, respectively.
Fig. 5-7. *Achnanthes lanceolata* var. *lanceolata*, x1250. Raphe and pseudoraphe valves, respectively.
Fig. 8-9. *Achnanthes lanceolata* var. *dubia*, x1250. Raphe and pseudoraphe valve, respectively.
Fig. 10-11. *Achnanthes lanceolata* var. *omissa*, x1250. Pseudoraphe valves.
Fig. 12. *Achnanthes lapponica* var. *ninckei*, x1250.
Fig. 13. *Achnanthes linearis* f. *curta*, x1250.
Fig. 14-15. *Achnanthes minutissima* var. *minutissima*, x1250.
Fig. 16. *Achnanthes* sp. 1, x1250.
Fig. 17. *Achnanthes* sp. 2, x1250.
Fig. 18. *Achnanthes* sp. 3, x1250.
Fig. 19. *Cocconeis diminuta* var. *diminuta*, x1250.
Fig. 20. *Cocconeis disculus* var. *disculus*, x1250.
Fig. 21. *Cocconeis hustedti* var. *hustedti*, x1250.
Fig. 22-23. *Cocconeis pediculus* var. *pediculus*, x1250. Raphe and pseudoraphe valve, respectively.
Fig. 24. *Cocconeis placentula* var. *placentula*, x1250.
Fig. 25. *Cocconeis placentula* var. *euglypta*, x1250.
Fig. 26. *Anomoeoneis vitrea* var. *vitrea*, x1250.
Fig. 27. *Cocconeis placentula* var. *lineata*, x1250.
Fig. 28. *Caloneis bacillum* var. *bacillum*, x1250.
Fig. 29. *Caloneis clevei* var. *uruguayensis*, x1250.
Fig. 30. *Navicula laevissima* var. *laevissima*, x1250.

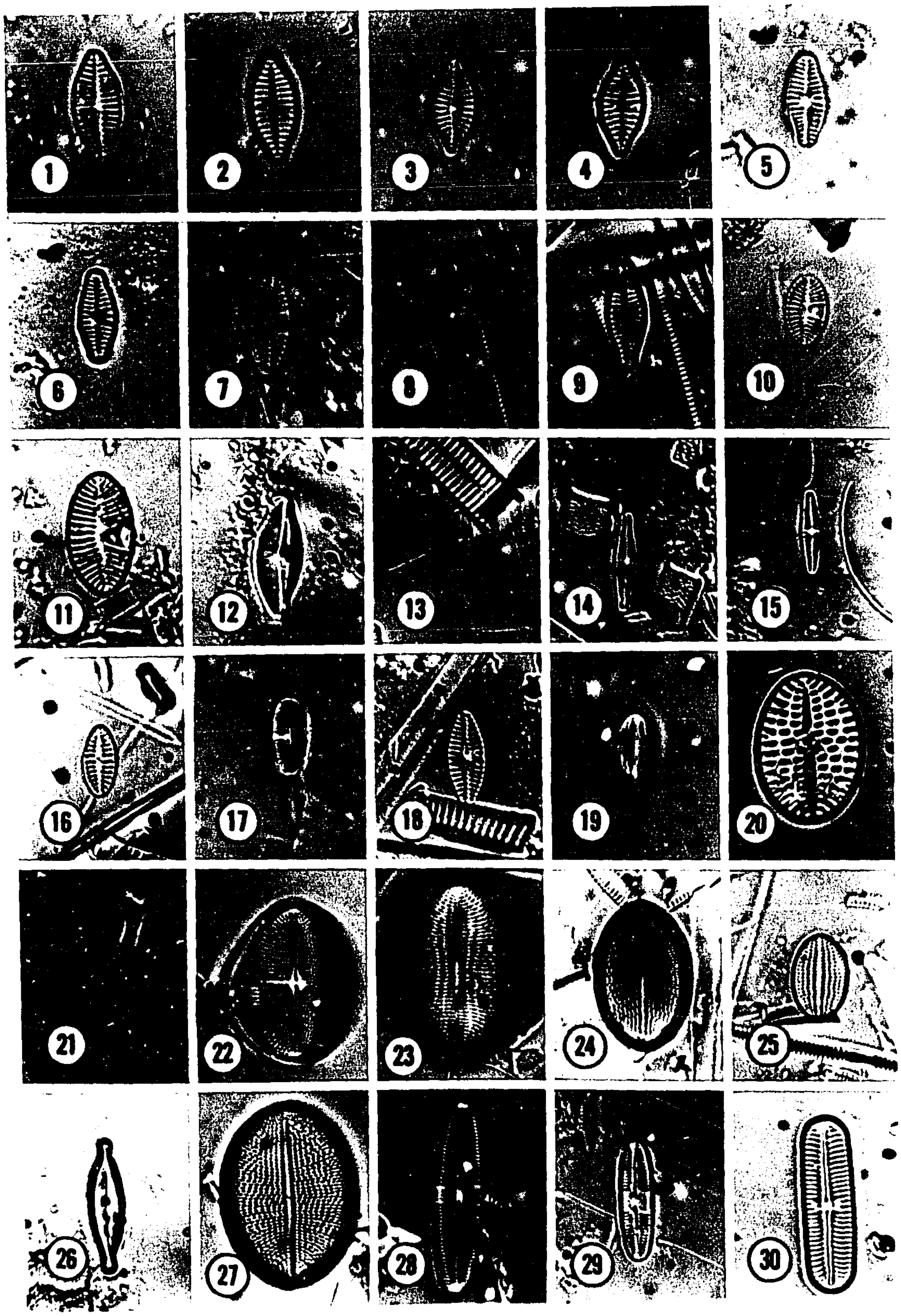
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Plate 13

Fig. 1.	Cocconeis placentula, x1250.
Fig. 2.	Caloneis ventricosa var. ventricosa, x1250.
Fig. 3,5.	Neidium sp. 1, x500 and x1250, respectively.
Fig. 4.	Diploneis oculata var. oculata, x1250.
Fig. 6.	Neidium iridis var. iridis, x1250.
Fig. 7,9.	Gyrosigma sciotense var. sciotense, x500 and x1250, respectively.
Fig. 8.	Neidium iridis var. ampliatum, x1250.
Fig. 10-11.	Gyrosigma spencerii var. spencerii, x1250.
Fig. 12.	Navicula platycephala var. platycephala, x1250.
Fig. 13.	Navicula subrotundata var. subrotundata, x1250.
Fig. 14.	Navicula tantula var. tantula, x1250.

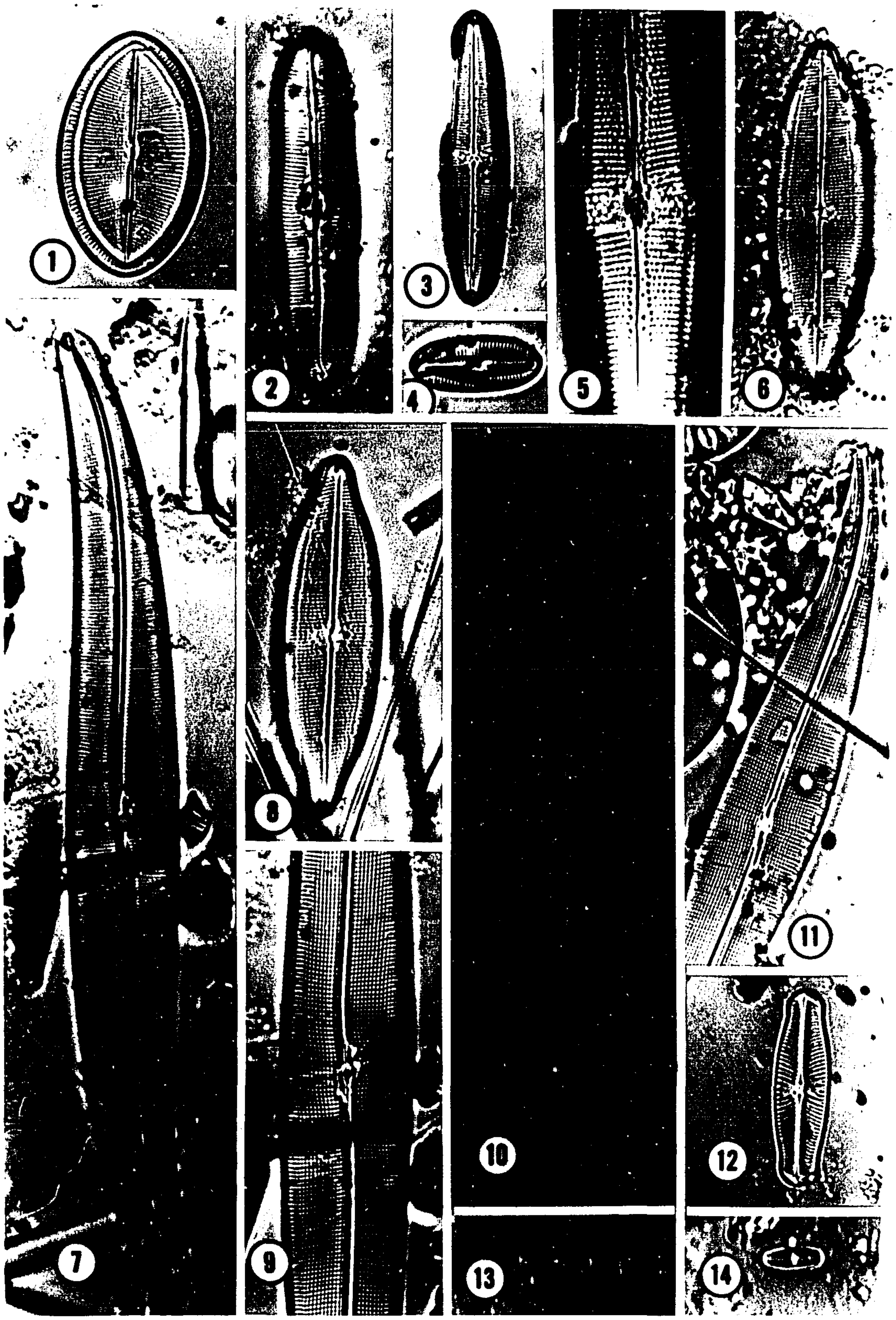
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Plate 14

Fig. 1. *Gyrosigma attenuatum* var. *attenuatum*, x500.
Fig. 2. *Navicula tripunctata* var. *tripunctata*, x1250.
Fig. 3. *Navicula cuspidata* var. *cuspidata*, x1250.
Fig. 4. *Navicula gottlandica* var. *gottlandica*, x1250.
Fig. 5. *Amphipleura pellucida* var. *pellucida*, x1250.
Fig. 6. *Navicula radiosa* var. *radiosa*, x1250.
Fig. 7. *Navicula* sp. 13, x1250.
Fig. 8. *Navicula pygmea* var. *pygmea*, x1250.
Fig. 9. *Navicula tuscula* f. *minor*, x1250.
Fig. 10. *Gyrosigma attenuatum* var. *attenuatum*, x1250.
Fig. 11. *Gyrosigma* sp. 1, x625.
Fig. 12. *Navicula menisculus* var. *menisculus*, x1250.

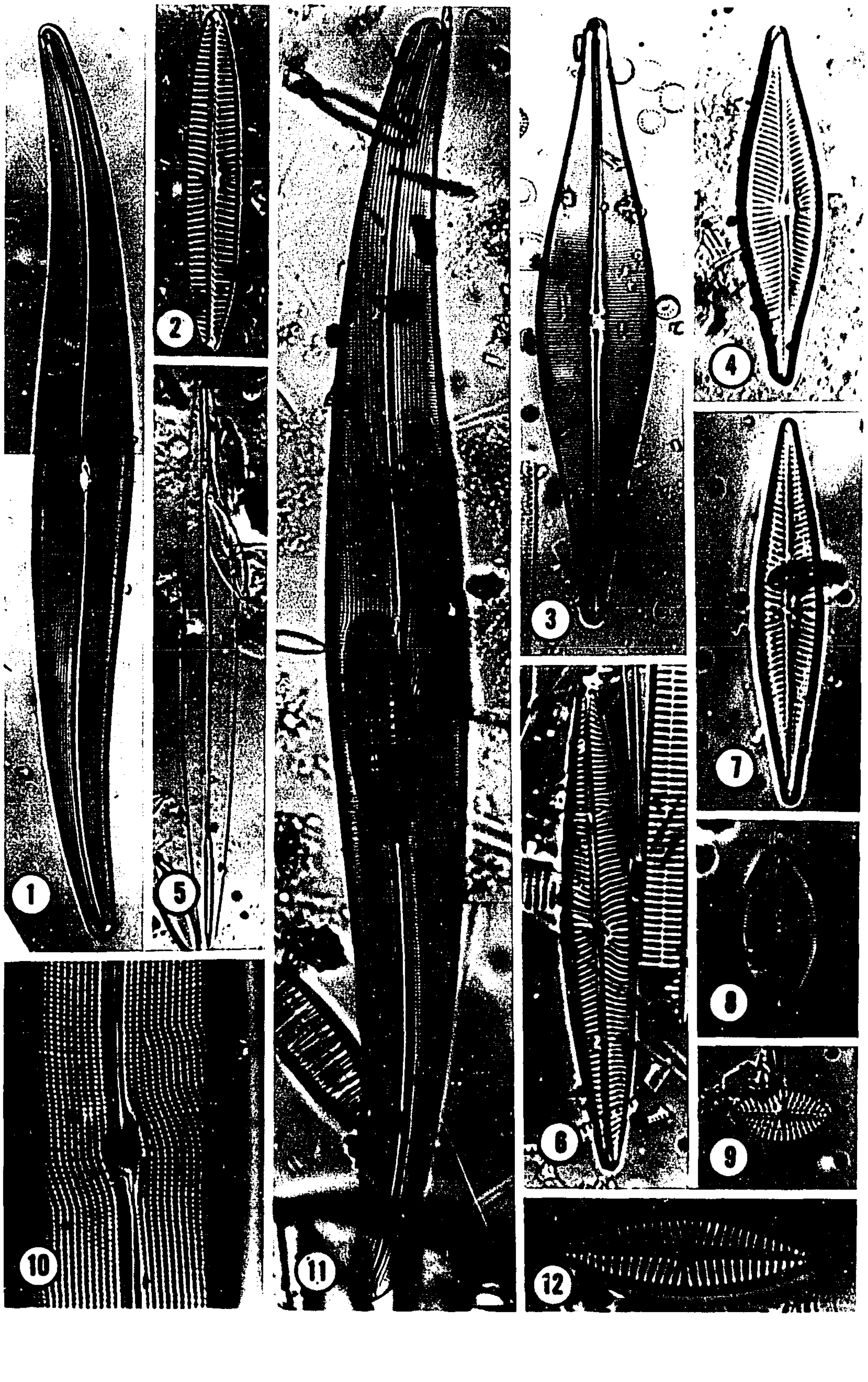
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Plate 15

Fig. 1. _Navicula biconica_ var. _biconica_, x1250.
Fig. 2. _Navicula capitata_ var. _capitata_, x1250.
Fig. 3. _Navicula capitata_ var. _hungarica_, x1250.
Fig. 4. _Navicula cocconeiformis_ var. _cocconeiformis_, x1250.
Fig. 5. _Navicula cryptocephala_ var. _veneta_, x1250.
Fig. 6. _Navicula exigua_ var. _capitata_, x1250.
Fig. 7. _Navicula latens_ var. _latens_, x1250.
Fig. 8. _Navicula minima_ var. _minima_, x1250.
Fig. 9. _Navicula mutica_ var. _mutica_, x1250.
Fig. 10. _Navicula nigrii_ var. _nigrii_, x1250.
Fig. 11. _Navicula pelliculosa_ var. _pelliculosa_, x1250.
Fig. 12. _Navicula pupula_ var. _pupula_, x1250.
Fig. 13. _Navicula pupula_ var. _capitata_, x1250.
Fig. 14. _Navicula pupula_ var. _elliptica_, x1250.
Fig. 15. _Navicula pseudoreinhardtii_ var. _pseudoreinhardtii_, x1250.
Fig. 16. _Navicula cryptocephala_ var. _cryptocephala_, x1250.
Fig. 17. _Navicula elata_ var. _elata_, x1250.
Fig. 18. _Navicula decussis_ var. _decussis_, x1250.
Fig. 19. _Navicula graciloides_ var. _graciloides_, x1250.
Fig. 20. _Navicula placentula_ var. _placentula_, x1250.
Fig. 21. _Navicula radiosa_ var. _parva_, x1250.
Fig. 22. _Navicula radiosa_ var. _tenella_, x1250.
Fig. 23. _Navicula reinhardtii_ var. _reinhardtii_, x1250.
Fig. 24. _Navicula scutelloides_ var. _scutelloides_, x1250.
Fig. 25. _Navicula salinarum_ var. _intermedia_, x1250.

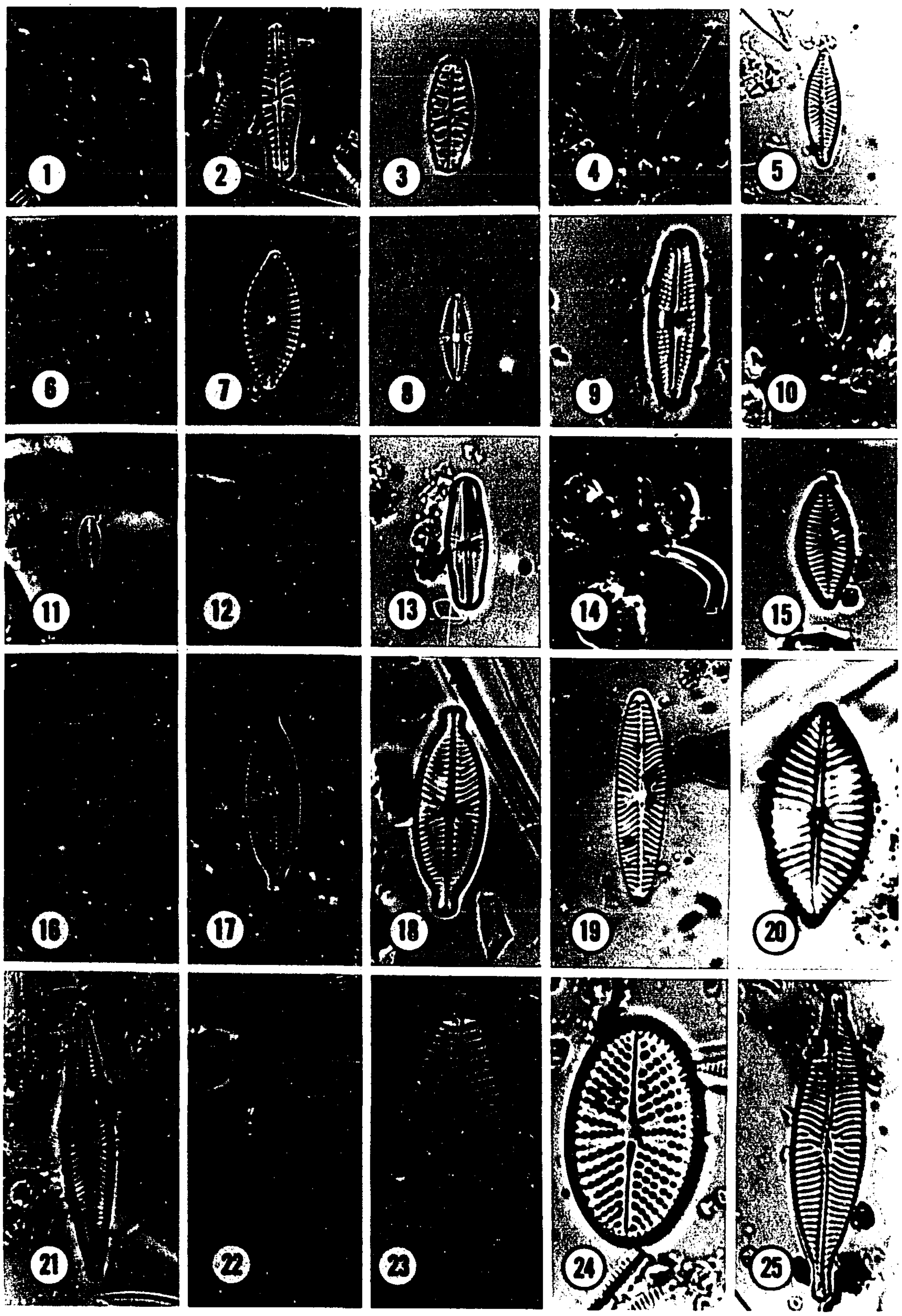
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Plate 16

Fig. 1. *Navicula placentula* f. *rostrata*, x1250.
Fig. 2. *Navicula tripunctata* var. *schizonemoides*, x1250.
Fig. 3. *Navicula tuscula* var. *tuscula*, x1250.
Fig. 4. *Navicula tuscula* f. *rostrata*, x1250.
Fig. 5. *Navicula simplex* var. *simplex*, x1250.
Fig. 6. *Navicula viridula* var. *argunensis*, x1250.
Fig. 7. *Navicula* sp. 1, x1250.
Fig. 8. *Navicula* sp. 2, x1250.
Fig. 9. *Navicula* sp. 5, x1250.
Fig. 10. *Navicula* sp. 6, x1250.
Fig. 11. *Navicula* sp. 7, x1250.
Fig. 12. *Navicula* sp. 8, x1250.
Fig. 13. *Navicula* sp. 9, x1250.
Fig. 14. *Navicula* sp. 14, x1250.
Fig. 15. *Navicula* sp. 11, x1250.
Fig. 16. *Navicula* sp. 15, x1250.
Fig. 17. *Navicula* sp. 3, x1250.
Fig. 18. *Navicula* sp. 10, x1250.
Fig. 19. *Navicula* sp. 12, x1250.
Fig. 20. *Navicula* sp. 4, x1250.

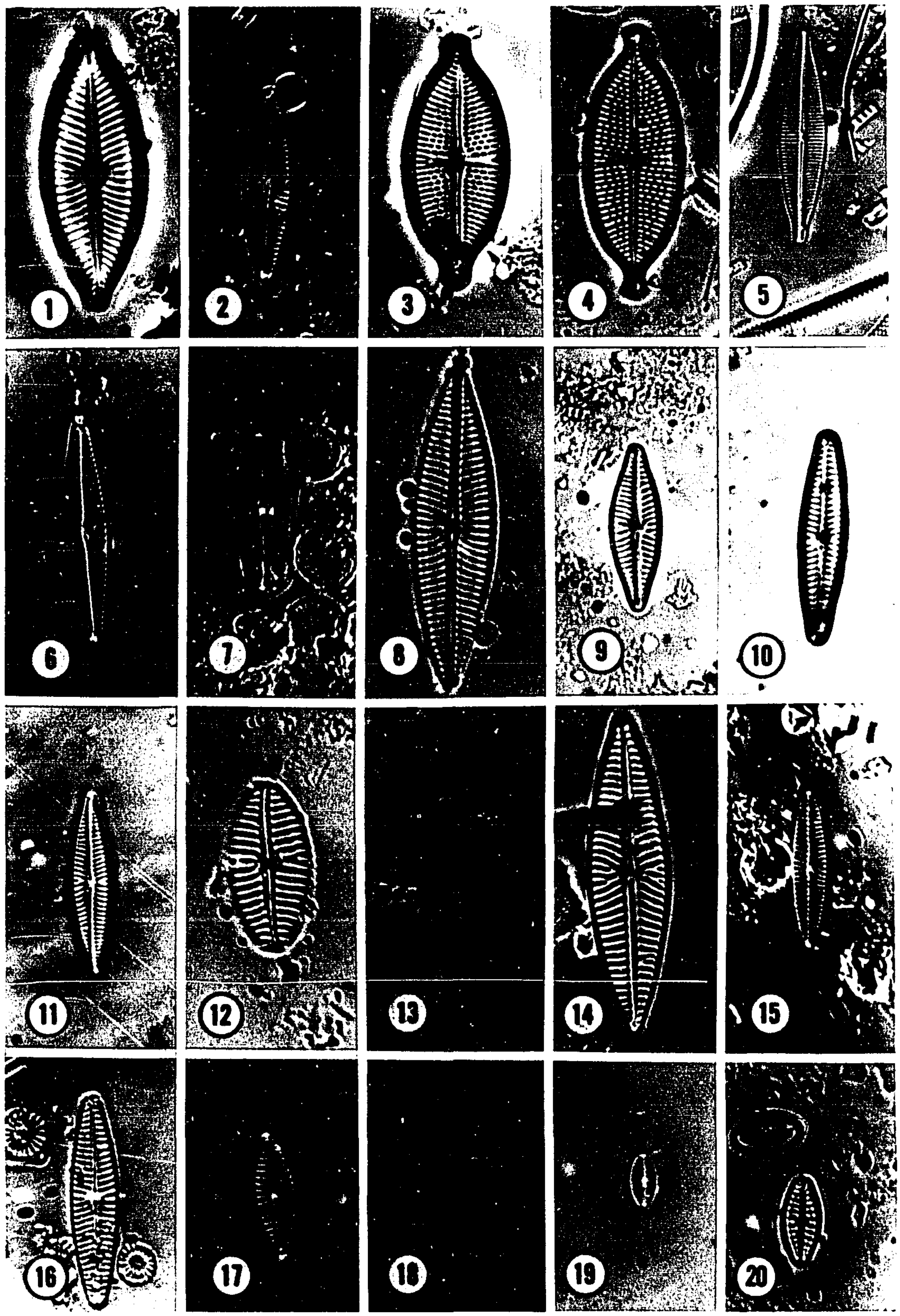
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Plate 17

Fig. 1. <u>Navicula</u> <u>laevissima</u> var. <u>laevissima</u>, x1250.
Fig. 2. <u>Pinnularia</u> <u>maior</u> var. <u>maior</u>, x1250.
Fig. 3. <u>Pinnularia</u> <u>viridis</u> var. <u>viridis</u>, x1250.
Fig. 4. <u>Entomoneis</u> <u>ornata</u> var. <u>ornata</u>, x1250.
Fig. 5. <u>Pinnularia</u> <u>brebissonii</u> var. <u>brebissonii</u>, x1250.
Fig. 6. <u>Pinnularia</u> sp. 1, x1250.
Fig. 7. <u>Gomphonema</u> <u>acuminatum</u> f. <u>brebissonii</u>, x1250.
Fig. 8. <u>Gomphonema</u> <u>affine</u> var. <u>affine</u>, x1250.
Fig. 9. <u>Gomphonema</u> <u>angustatum</u> var. <u>angustatum</u>, x1250.
Fig. 10. <u>Gomphonema</u> <u>angustatum</u> var. <u>intermedia</u>, x1250.
Fig. 11. <u>Gomphonema</u> <u>angustatum</u> var. <u>citera</u>, x1250.
Fig. 12. <u>Gomphonema</u> <u>clevei</u> var. <u>clevei</u>, x1250.

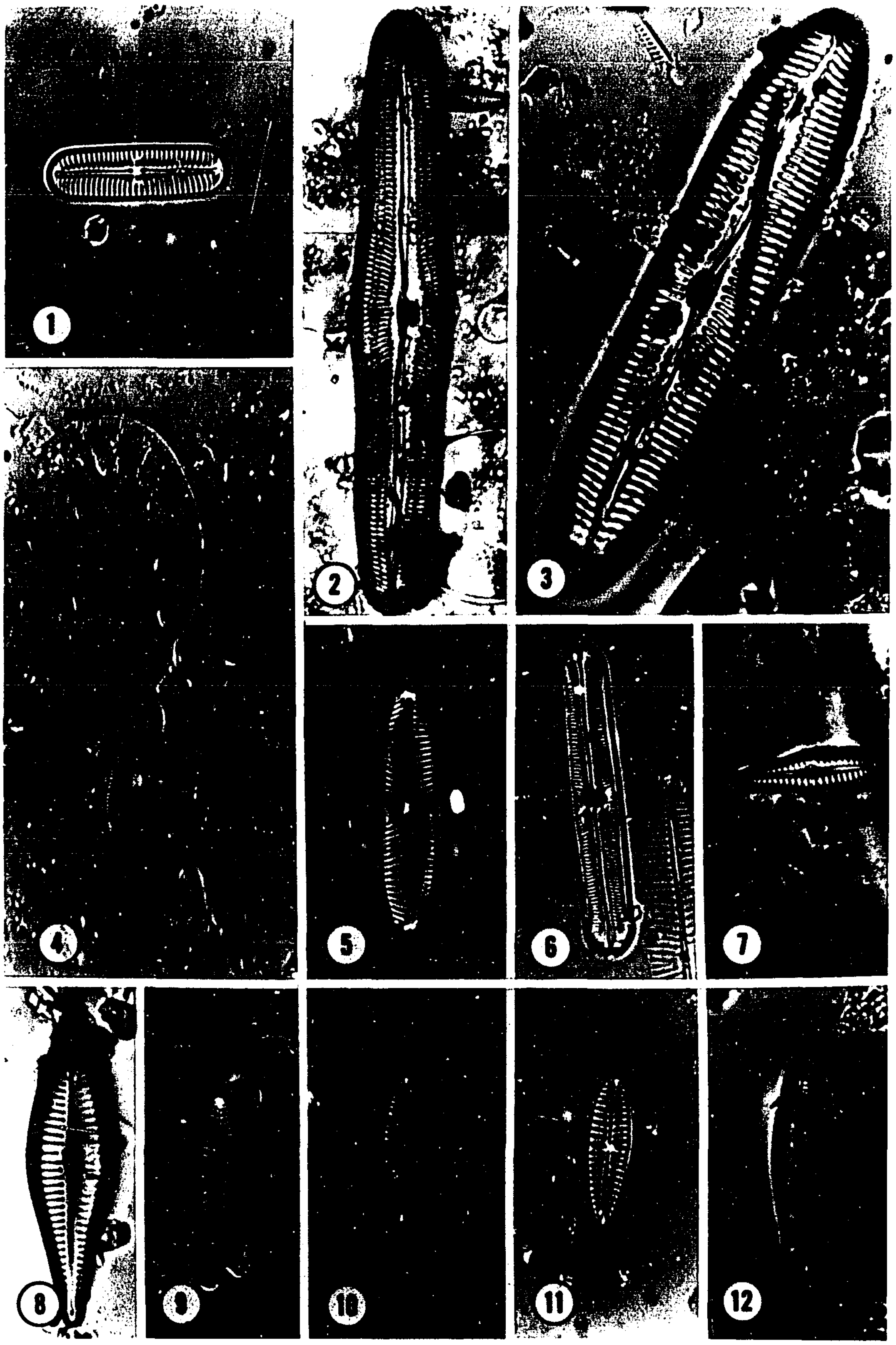
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Plate 18

Fig. 1. Gomphonema dichotum var. dichotum, x1250.
Fig. 2. Gomphonema gracile var. gracile, x1250.
Fig. 3. Gomphonema intricatum var. pumila, x1250.
Fig. 4. Gomphonema intricatum var. intricatum, x1250.
Fig. 5. Gomphonema intricatum var. vibrio, x1250.
Fig. 6. Gomphonema olivaceoides var. olivaceoides, x1250.
Fig. 7. Gomphonema olivaceum var. olivaceum, x1250.
Fig. 8. Gomphonema parvulum var. parvulum, x1250.
Fig. 9. Gomphonema subclavatum var. comutatum, x1250.
Fig. 10. Gomphonema subclavatum var. mexicanum, x1250.
Fig. 11. Gomphonema truncatum var. truncatum, x1250.
Fig. 12. Gomphonema sp. 1, x1250.
Fig. 13. Gomphonema sp. 2, x1250.
Fig. 14. Gomphonema sp. 5, x1250.
Fig. 15. Gomphonema sp. 7, x1250.
Fig. 16. Gomphonema sp. 4, x1250.
Fig. 17. Gomphonema sp. 6, x1250.
Fig. 18. Gomphonema sp. 11, x1250.
Fig. 19. Gomphonema sp. 8, x1250.
Fig. 20. Gomphoneis erinse var. erinse, x1250.

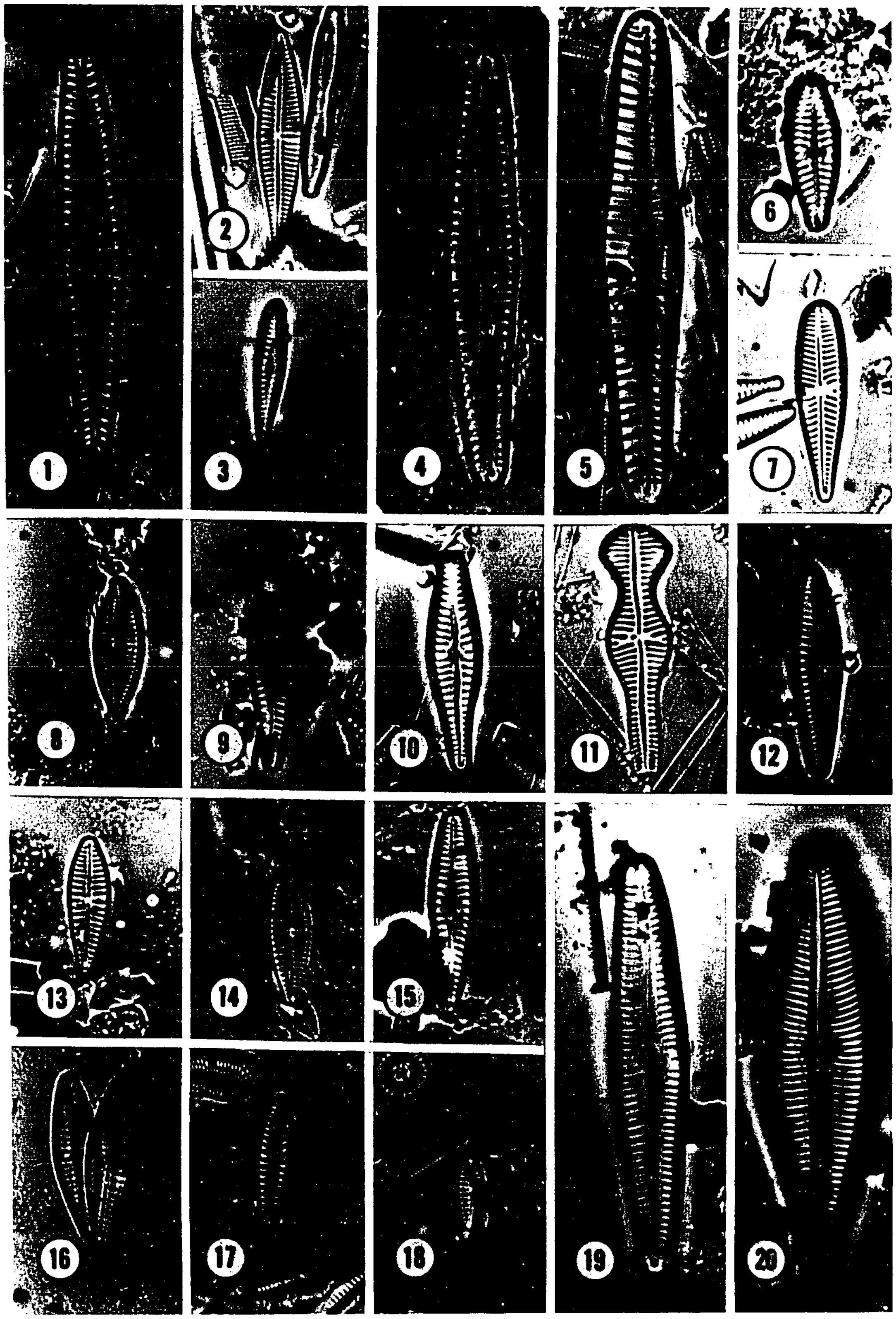
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Plate 19

Fig. 1. *Gomphonema* sp. 3, x1250.
Fig. 2. *Gomphonema* sp. 9, x1250.
Fig. 3. *Gomphonema* sp. 10, x1250.
Fig. 4. *Amphora ovalis* var. *ovalis*, x1250.
Fig. 5. *Amphora ovalis* var. *affinis*, x1250.
Fig. 6. *Amphora ovalis* var. *pediculus*, x1250.
Fig. 7. *Amphora perpusilla* var. *perpusilla*, x1250.
Fig. 8. *Amphora ovalis* var. *ovalis*, x1250.
Fig. 9. *Amphora veneta* var. *veneta*, x1250.
Fig. 10. *Cymbella aspersa* var. *aspersa*, x1250.
Fig. 11. *Cymbella affinis* var. *affinis*, x1250.
Fig. 12-13. *Cymbella aspersa* var. *aspersa*, x1250. Central region of valve and distal raphe end, respectively.

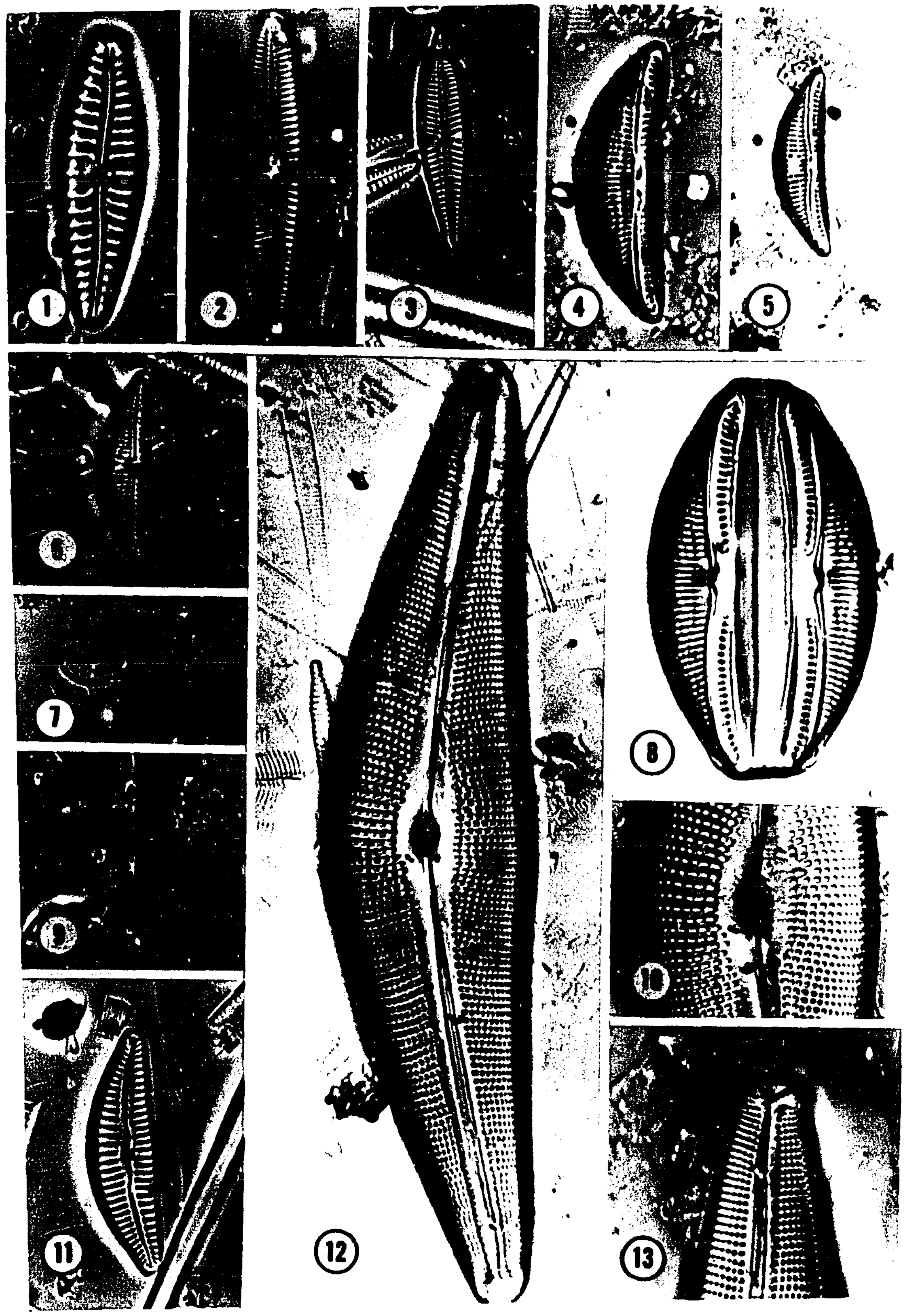
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Plate 20

Fig. 1. *Cymbella cistula* var. *cistula*, x1250.
Fig. 2. *Cymbella cuspidata* var. *cuspidata*, x1250.
Fig. 3. *Cymbella mexicana* var. *mexicana*, x500.
Fig. 4. *Cymbella cymbiformis* var. *cymbiformis*, x1250.
Fig. 5. *Cymbella lanceolata* var. *lanceolata*, x1250.
Fig. 6. *Cymbella prostrata* var. *prostrata*, x1250.
Fig. 7. *Cymbella mexicana* var. *mexicana*, x1250. Central area of valve.
Fig. 8. *Cymbella minuta* var. *minuta*, x1250.
Fig. 9. *Cymbella microcephala* var. *microcephala*, x1250.
Fig. 10. *Cymbella minuta* var. *silesiaca*, x1250.

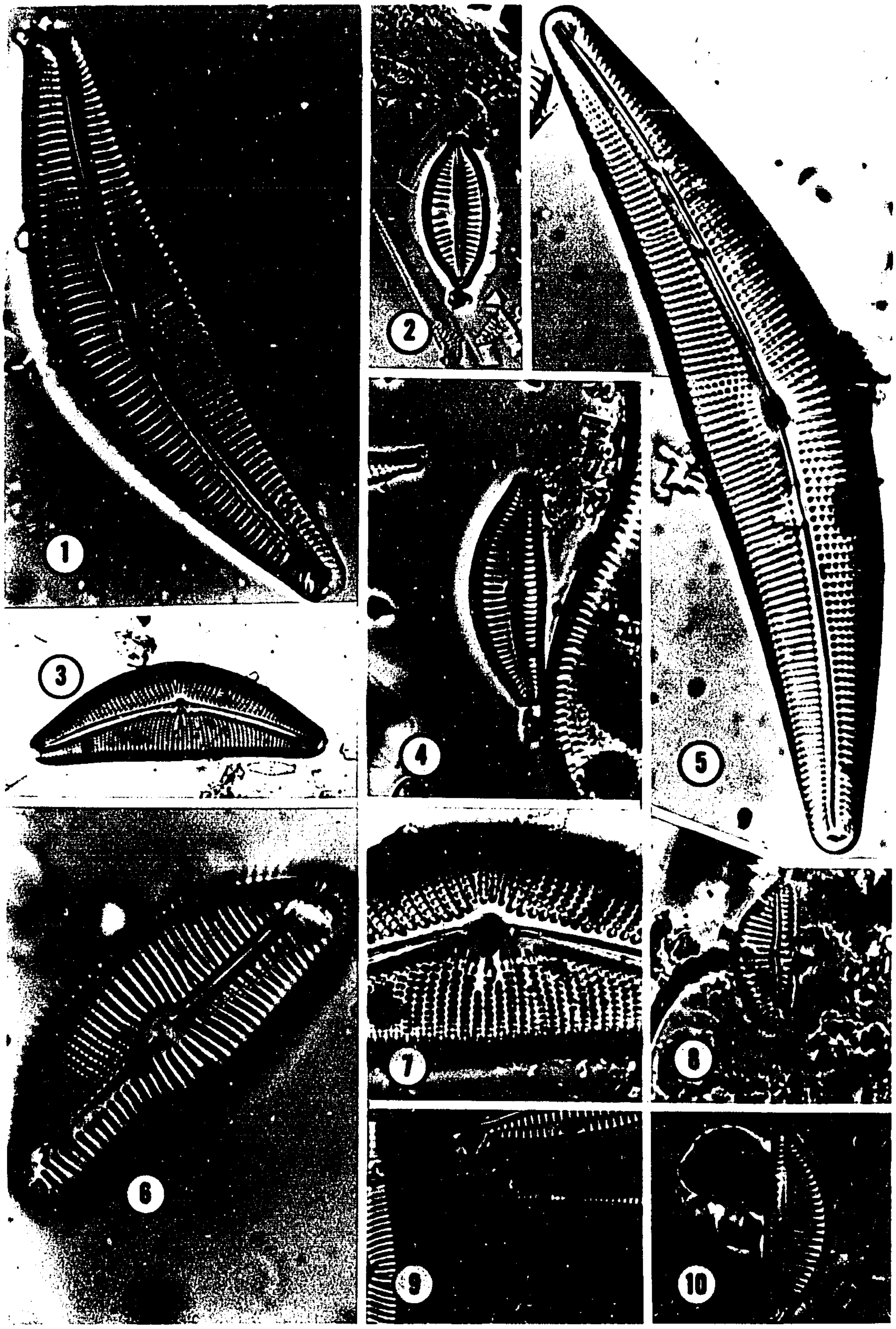
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Plate 21

Fig. 1. *Cymbella muelleri* var. *ventricosa*, x1250.
Fig. 2-3. *Cymbella muelleri* var. *muelleri*, x1250.
Fig. 4. *Cymbella proxima* var. *proxima*, x1250.
Fig. 5-6. *Cymbella triangulatum* var. *triangulatum*, x1250.
Fig. 7. *Cymbella sinuata* var. *sinuata*, x1250.
Fig. 8. *Nitzschia acuta* var. *acuta*, x1250.
Fig. 9. *Nitzschia acicularis* var. *acicularis*, x1250.
Fig. 10-11. *Nitzschia amphibia* var. *amphibia*, x1250.

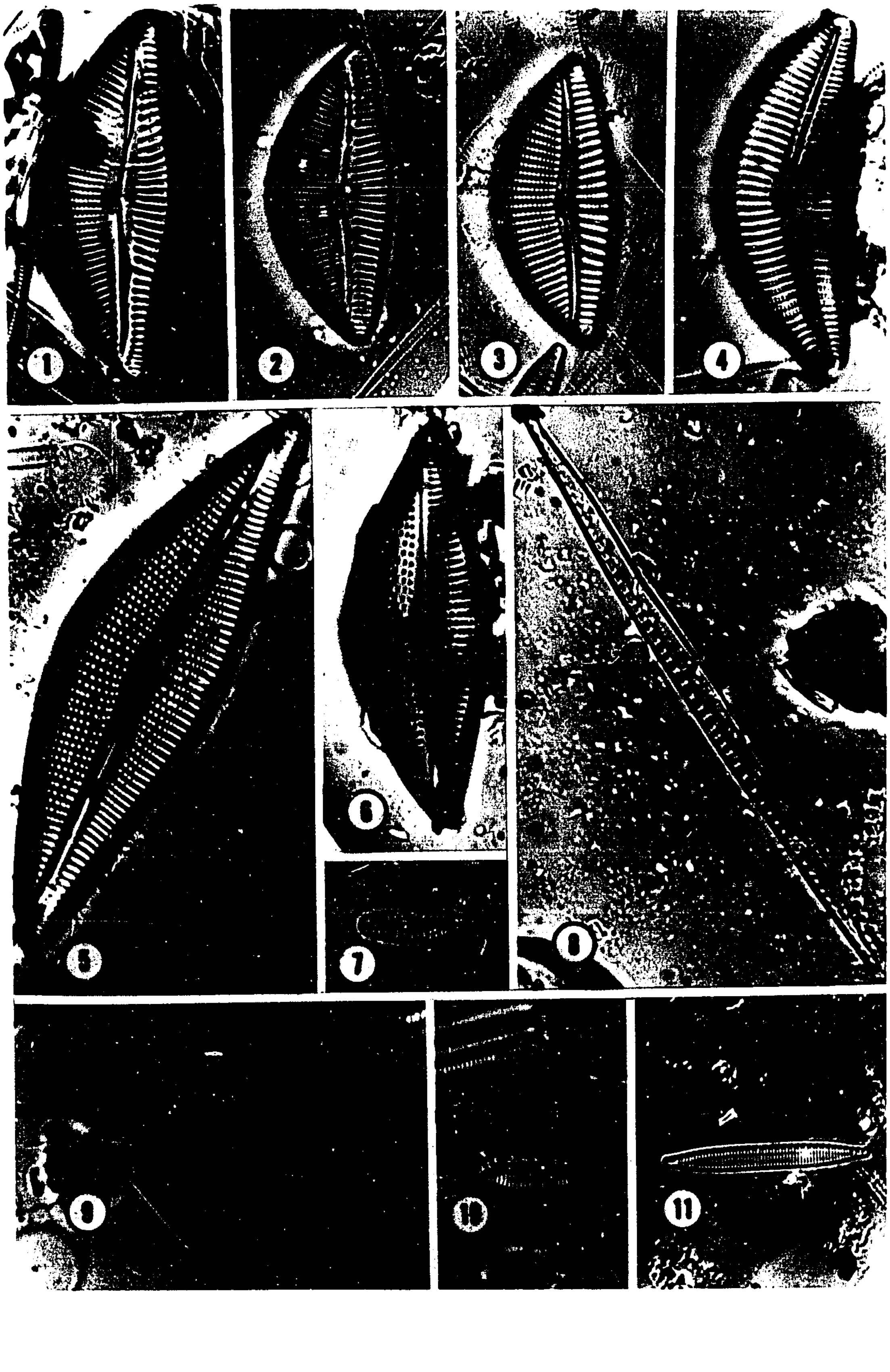
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Plate 22

Fig. 1. <u>Nitzschia</u> <u>capitellata</u> var. <u>capitellata</u>, x1250.
Fig. 2. <u>Nitzschia</u> <u>angustata</u> var. <u>angustata</u>, x1250.
Fig. 3. <u>Nitzschia</u> <u>commutata</u> var. <u>commutata</u>, x1250.
Fig. 4. <u>Nitzschia</u> <u>dissipata</u> var. <u>dissipata</u>, x1250.
Fig. 5. <u>Nitzschia</u> <u>filiformis</u> var. <u>filiformis</u>, x1250.
Fig. 6. <u>Nitzschia</u> <u>fonticola</u> var. <u>fonticola</u>, x1250.
Fig. 7. <u>Nitzschia</u> <u>frustulum</u> var. <u>perpusilla</u>, x1250.
Fig. 8. <u>Nitzschia</u> <u>gracilis</u> var. <u>gracilis</u>, x1250.
Fig. 9. <u>Nitzschia</u> <u>hungarica</u> var. <u>hungarica</u>, x1250.
Fig. 10. <u>Nitzschia</u> <u>kutzingiana</u> var. <u>kutzingiana</u>, x1250.
Fig. 11. <u>Nitzschia</u> <u>recta</u> var. <u>recta</u>, x1250.
Fig. 12. <u>Nitzschia</u> <u>palea</u> var. <u>palea</u>, x1250.
Fig. 13. <u>Nitzschia</u> <u>pseudoamphioxys</u> var. <u>pseudoamphioxys</u>, x1250.
Fig. 14. <u>Nitzschia</u> <u>sinuata</u> var. <u>tabellaria</u>, x1250.
Fig. 15. <u>Nitzschia</u> sp. 2, x1250.

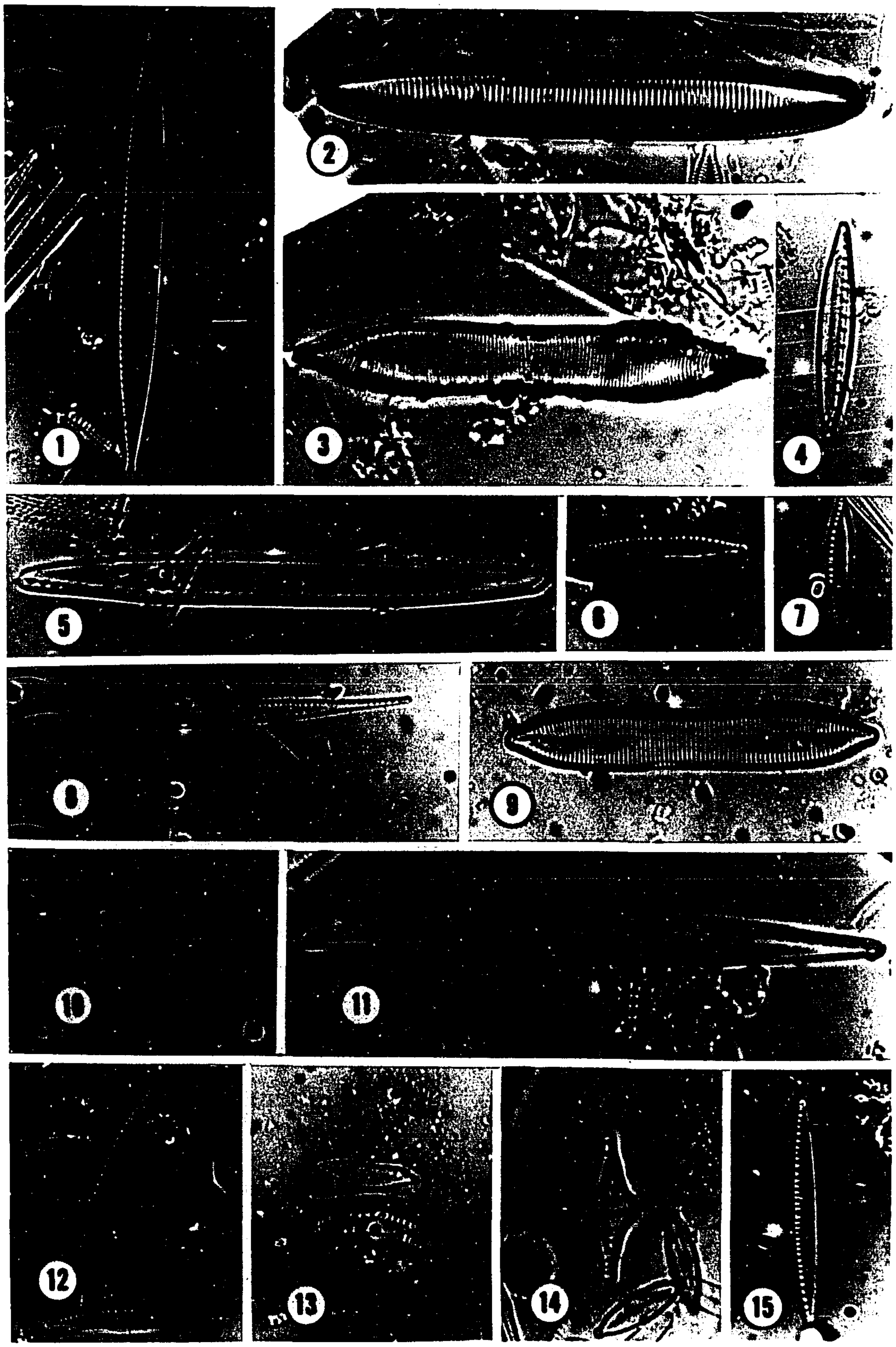
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Plate 23

Fig. 1. Nitzschia subrostratoides var. subrostratoides, x1250.
Fig. 2. Nitzschia triblionella var. levidensis, x1250.
Fig. 3. Nitzschia sp. 3, x1250.
Fig. 4-5. Nitzschia sigmoidea var. sigmoidea, x1250 and x500, respectively.
Fig. 6. Rhoicosphenia curvata var. curvata, x1250.
Fig. 7. Rhopalodia gibba var. gibba, x1250.
Fig. 8. Rhoicosphenia curvata var. curvata, x1250.
Fig. 9. Cymbellonitzschia diluviana var. diluviana, x1250.
Fig. 10. Surirella iowensis var. iowensis, x1250.
Fig. 11. Surirella ovata var. ovata, x1250.
Fig. 12. Surirella ovata var. pinnata, x1250.

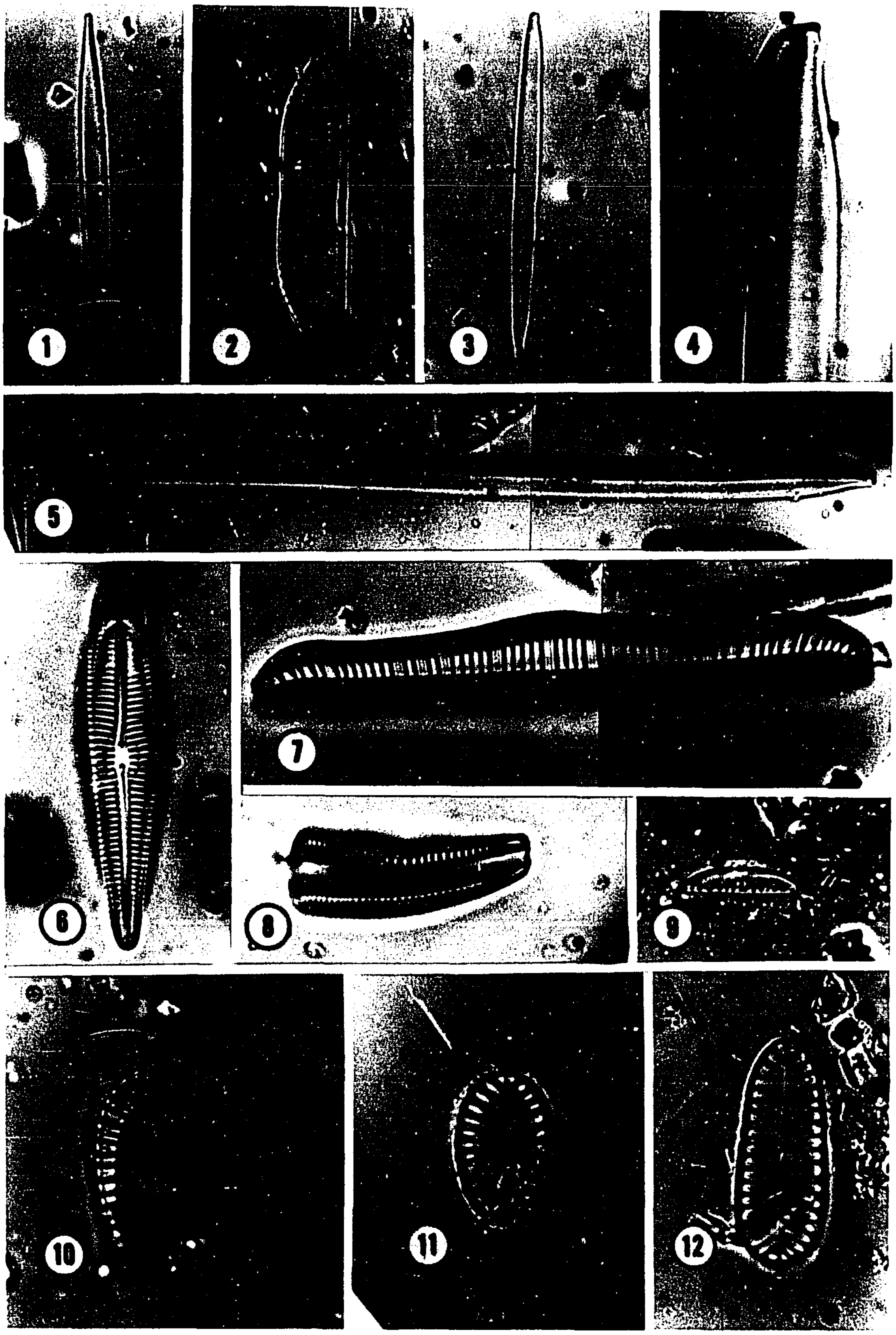
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Plate 24

Fig. 1. Surirella angusta var. angusta, x1250.

Fig. 2. Cymatopleura solea var. solea, x1250.

Fig. 3. Surirella guantanalensis var. guantanalensis, x500.

Fig. 4. Epithemia turgida var. westermanii, x1250.

Fig. 5. Epithemia adnata var. porcellus, x1250.

Fig. 6. Cymatopleura elliptica var. elliptica, x500.

Fig. 7. Epithemia oscellata var. oscellata, x1250.

Fig. 8. Nitzschia linearis var. linearis, x1250.

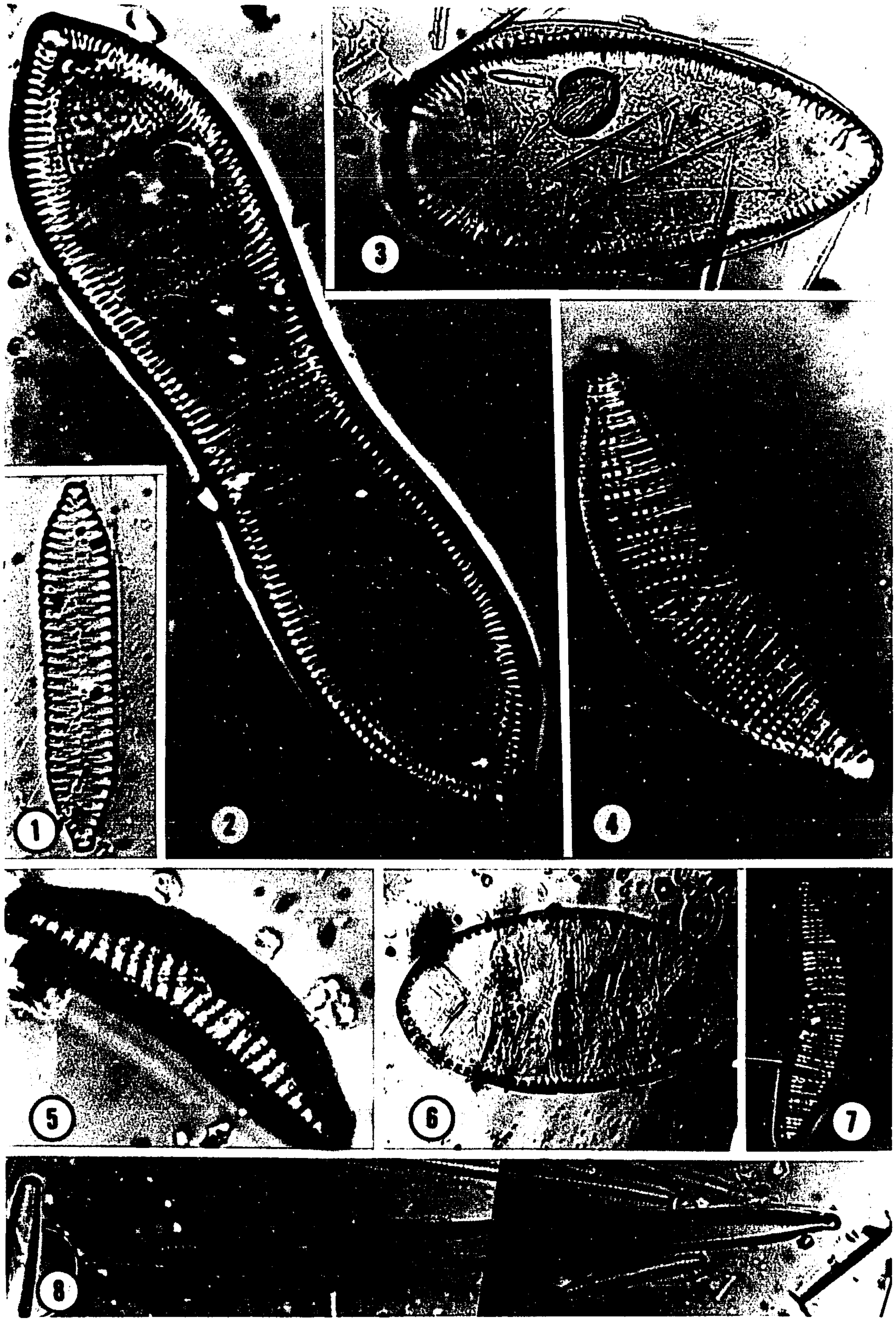
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Plate 25

Fig. 1. *Epithemia turgida* var. *westermanii*, x2500.
Fig. 2. *Cymatopleura cochlea* var. *cochlea*, x1000.
Fig. 3. *Surirella biseriata* f. *punctata*, x1000.
Fig. 4. *Epithemia intermedia* var. *intermedia*, x2500.

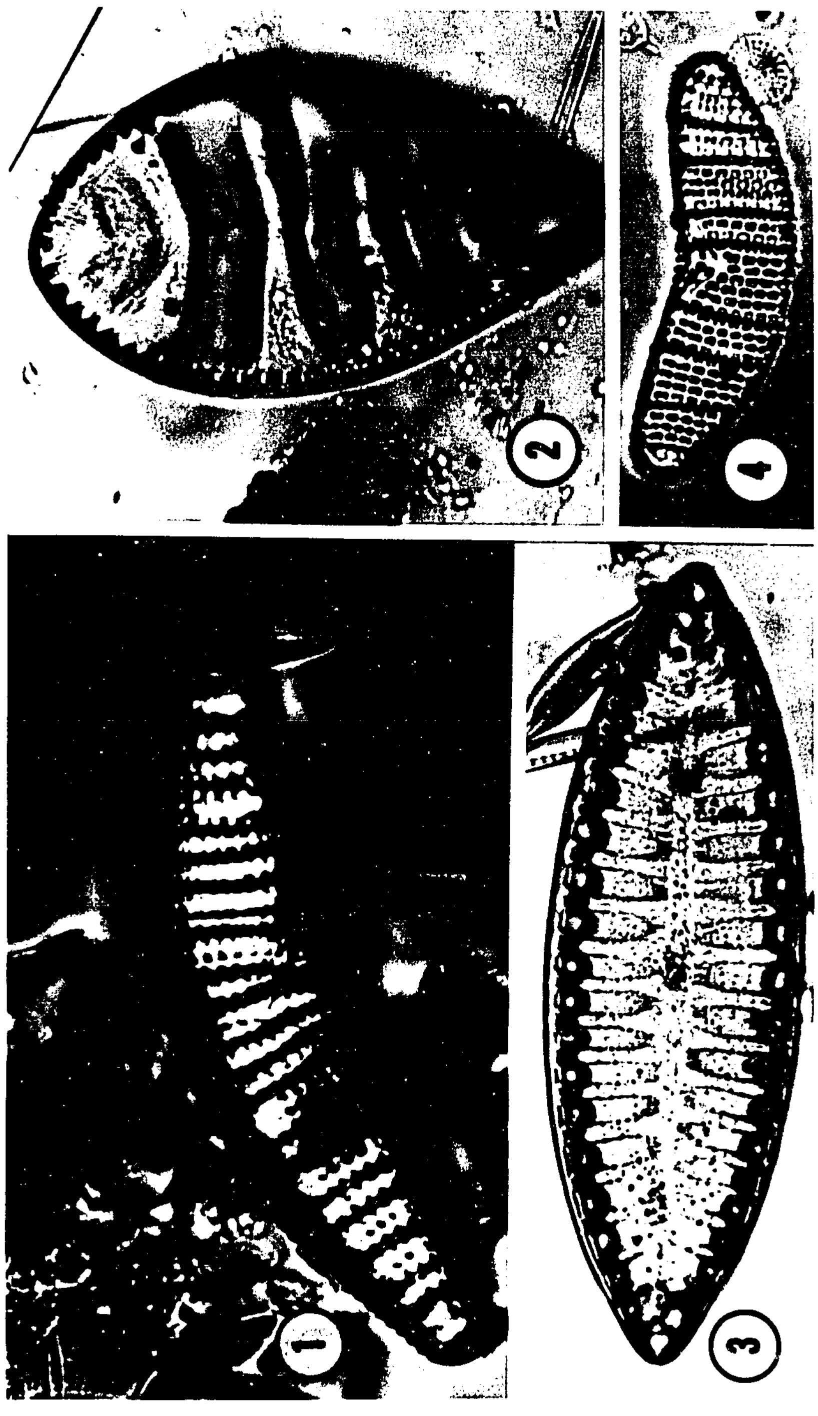
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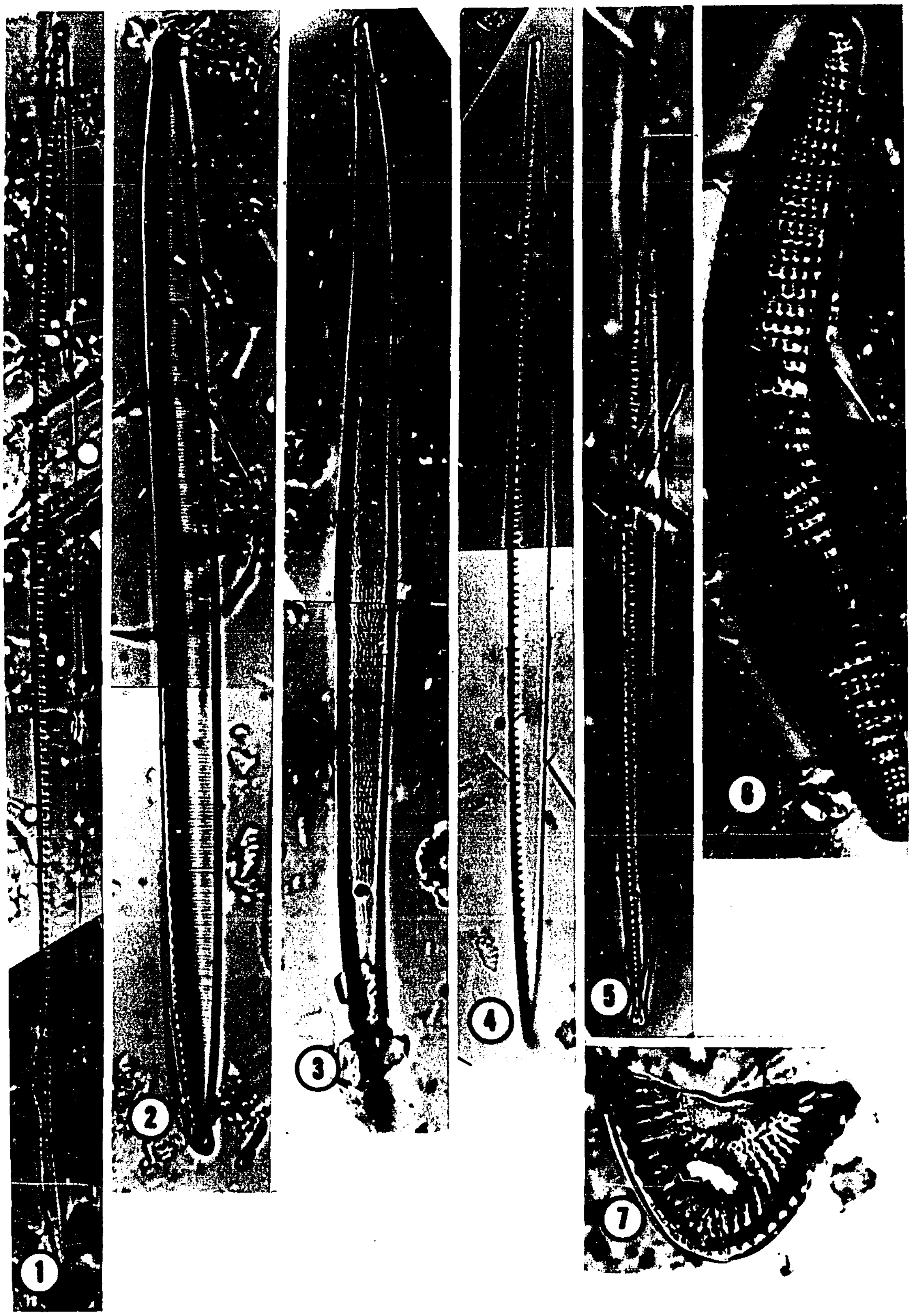
Plate 26

Fig. 1. *Nitzschia* sp. 1, x1250.
Fig. 2. *Nitzschia intermedia* var. *intermedia*, x1250.
Fig. 3. *Nitzschia sigma* var. *sigma*, x1250.
Fig. 4. *Nitzschia subtilioides* var. *subtilioides*, x1250.
Fig. 5. *Nitzschia vermicularis* var. *vermicularis*, x1250.
Fig. 6. *Epithemia turgida* var. *turgida*, x1250.
Fig. 7. *Campylodiscus noricus* var. *hiberica*, x1250.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Temporal Trends Within Lakes

To define the periodicity of the plankton diatom communities in the Region, I separated the diatoms into two major types, based upon the symmetry of the valves, as has been done traditionally (Heiden and Kolbe, 1928; Hustedt, 1930a; Silva, 1962). Species with radial symmetry were included in the centric diatoms and those with bilateral symmetry were placed in the pennate diatoms. The centrics, now placed in the order Eupodiscales (Table 4), were further subdivided into the subfamilies Melosiroideae and Coscinodiscoideae. These naming conventions remain in the "modern" classification scheme that I used during this study (Table 4). The pennates were traditionally further divided into four suborders on the basis of the number, location, and morphology of the raphe on the frustule (Hustedt, 1930a; Hendey, 1937): Araphidineae (no raphe); Monoraphidineae (raphe present on only one valve of the frustule); Biraphidineae (raphe on both valves of the frustule); and Raphidioidineae (reduced or rudimentary raphe on one or both of the valves). Though most recent classifications (Table 4) abandon these morphological divisions of the taxa, the descriptive terms are nonetheless convenient and are of some ecological significance.

The following discussion addresses the quantitative differences in the abundance of the major groups (centric and pennate) and subgroups (suborders or subfamilies) of the plankton diatoms within each lake; and the cycles of the common taxa.

Lake West Okoboji

Community composition The plankton diatom community of Lake West Okoboji was dominated by species of pennate diatoms (Figure 89). This group exhibited a bimodal abundance curve with peaks occurring during the late spring and summer, and the winter. All of the seasonal maxima of the pennate diatoms were accounted for by species belonging to the Araphidineae (Figure 90). Members of the Biraphidineae were common in the plankton only during the summer and fall, periods dominated by the centric diatoms (Figures 89 and 90). The Monoraphidineae were never a major component of the plankton. The peak abundances of the centric diatoms occurred during the early spring, late summer and fall, with a short-lived pulse during the late winter (Figure 89). Species of the centric diatom subfamily Coscinodiscoideae occurred during the spring, late fall and winter (Figure 91), while species of the Melosiroideae were most abundant during the summer and early fall.

Species succession The spring plankton of Lake West Okoboji was characterized by a low diversity (Figure 92) with a few species representing 80 - 90% of the standing crop. After ice break-up, the initial spring bloom of centric

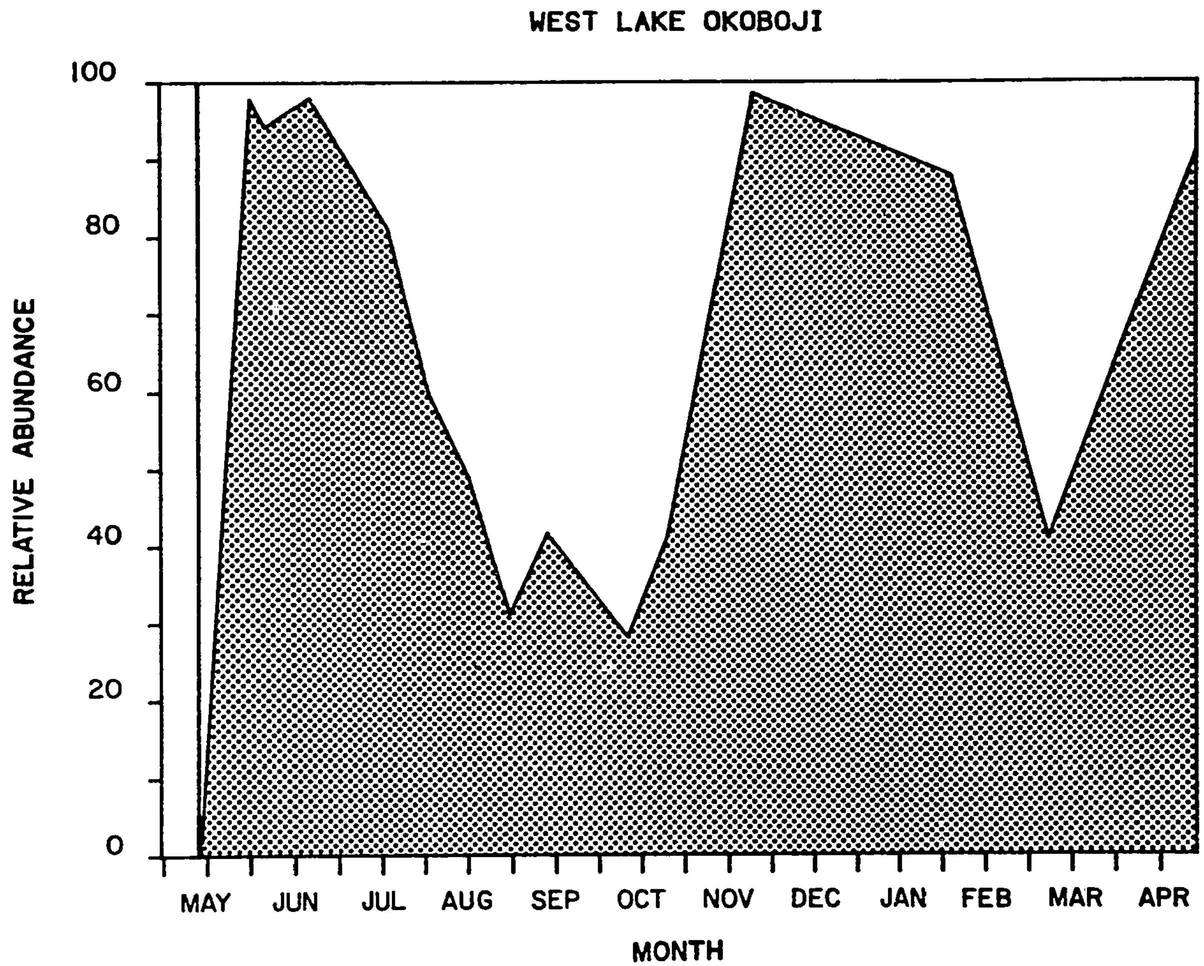

Figure 89. Relative abundance of centric and pennate diatoms in Lake West Okoboji. Centrics, white; pennates, shaded

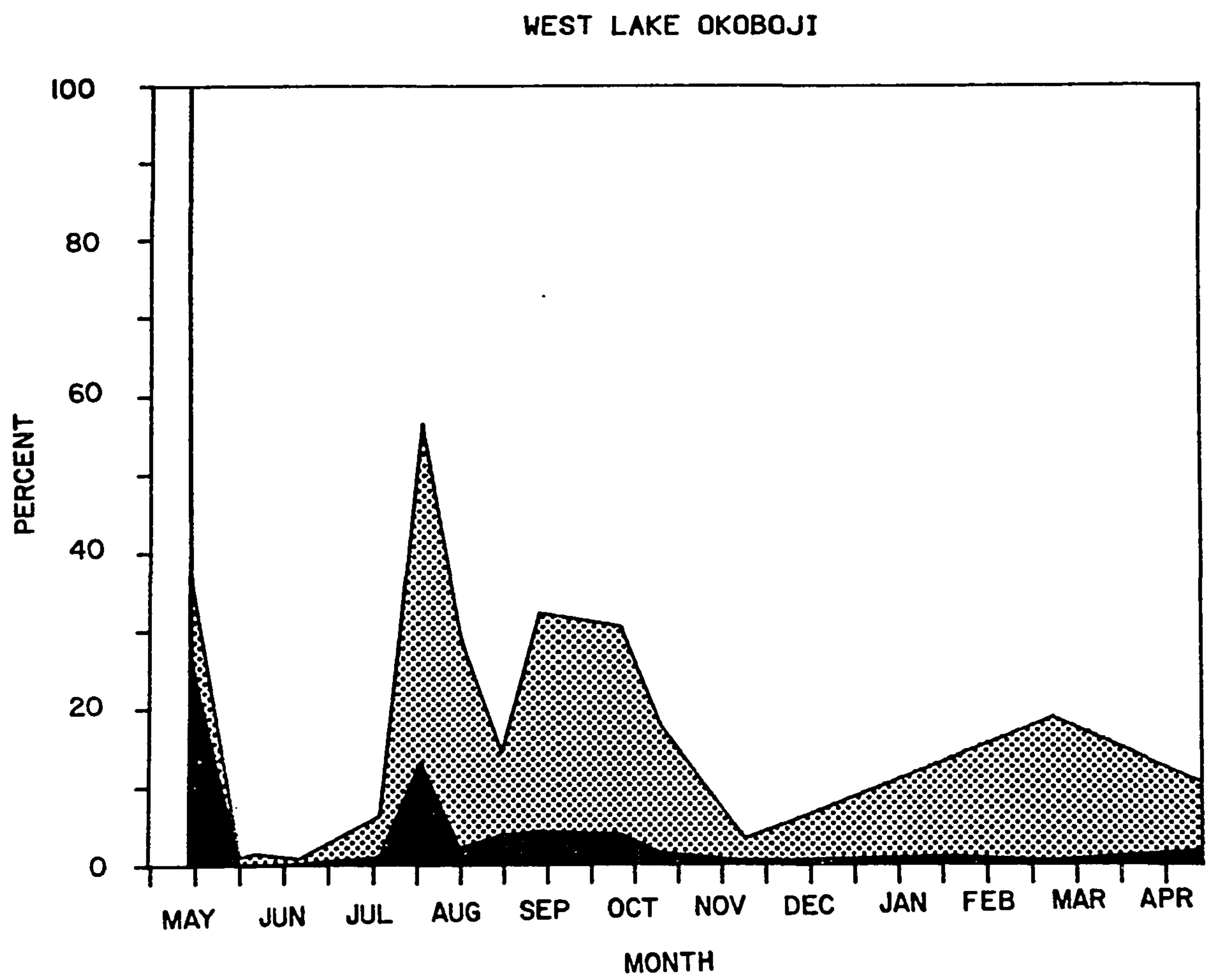

Figure 90. Percent composition of pennate diatom suborders (Hustedt, 1930a) in Lake West Okoboji. Monoraphidineae,black; Biraphidineae, shaded; Araphidineae, white

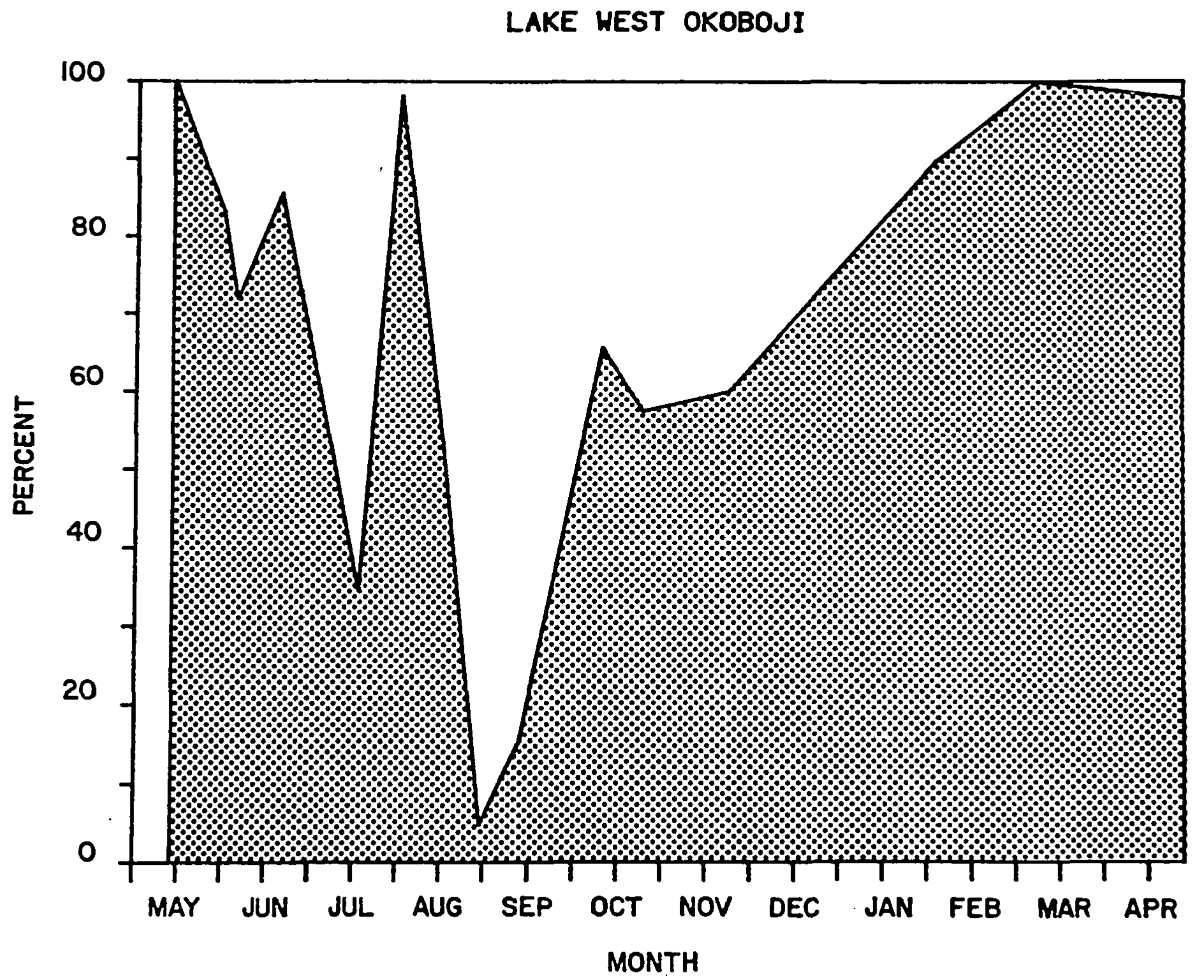

Figure 91. Percent composition of centric diatom subfamilies in Lake West Okoboji. Coscinodiscoideae, shaded; Melosiroideae, white

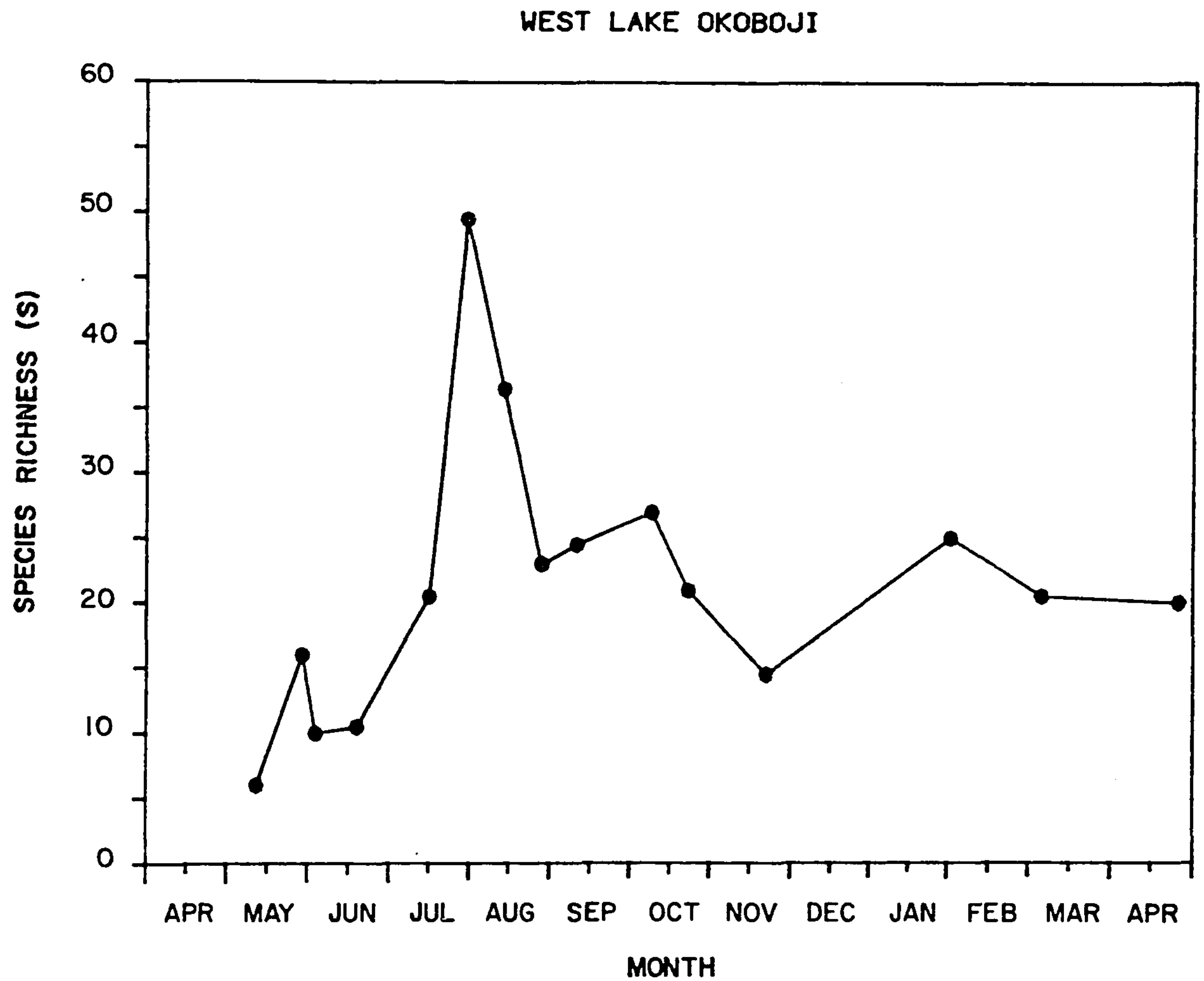

Figure 92. Species richness (S) by sampling date for Lake West Okoboji

diatoms, predominantly Stephanodiscus hantzschii (64%) and Stephanodiscus minutus (33%), was rapidly replaced by the pennate species, Fragilaria crotonensis (32%), Fragilaria capucina v. mesolepta (32%) and Asterionella formosa (24%). Fragilaria crotonensis became the dominant throughout the remainder of the spring maximum with a relative abundance ranging between 64 - 92%. With the onset of summer, the diatoms' contribution to the total standing crop declined, while the diversity of diatom species reached its maximum for the year (Figure 92) during late July. Stephanodiscus hantzschii, Stephanodiscus minutus, Amphora perpusilla, and Melosira granulata were common taxa. Overall diatom abundance remained supressed throughout the fall, with Melosira granulata and Melosira granulata v. angustissima predominating. The taxa reported for the summer plankton, Stephanodiscus spp. and Fragilaria spp., were also common during the fall. Stephanodiscus niagarae v. magnifica (22%) was a co-dominant with Melosira granulata (19%) and Asterionella formosa (17%) during late October. An autumnal pulse of Fragilaria capucina v. mesolepta (88%) occurred in November. Asterionella formosa and Fragilaria crotonensis were also frequently encountered, as the diversity of taxa dropped to levels comparable to the early spring (Figure 92). During the winter ice cover the number of species increased while the abundance of the plankton declined. Fragilaria capucina v. mesolepta, Fragilaria vaucheriae, Stephanodiscus hantzschii, Stephanodiscus minutus, and Asterionella formosa were the predominant winter forms. These species remained co-dominants into the early spring (April, 1980) following the spring overturn.

Lake East Okoboji

Community composition The general picture is of a plankton diatom community dominated by pennates (Figure 93). Members of the Araphidineae were predominant during the spring, early summer, and the winter, while taxa belonging to the Biraphidineae commonly occurred during the late summer and fall (Figure 94). The frequency of occurrence of the Monoraphidineae increased during the summer and fall, but this group never contributed significantly to the plankton standing crop (Figure 94). The centric diatoms exhibited several peaks in abundance during the spring and summer (Figure 93), but were only a minor component of the flora during the fall and winter. Members of the Coscinodiscoideae were generally the most frequently encountered centric taxa during all seasons (Figure 95). Pulses of the Melosiroideae occurred during July, August, November, and April, but the group was typically more common in the late summer and fall plankton (Figure 95).

Species succession The vernal diatom maximum was dominated by the centric diatom, Stephanodiscus hantzschii (45 - 67%), and the diversity was low (Figure 96). The standing

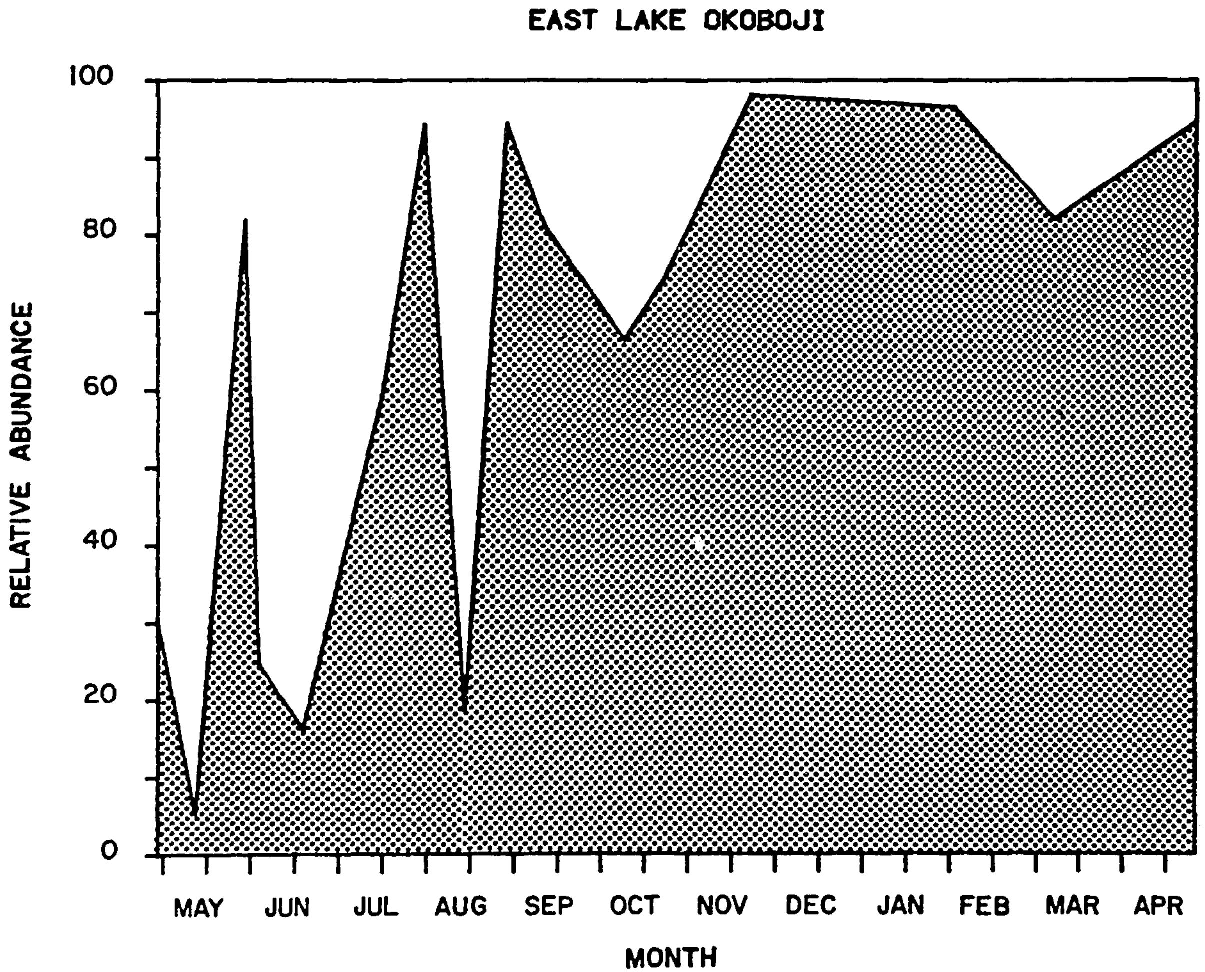

Figure 93. Relative abundance of centric and pennate diatoms in Lake East Okoboji. Centrics, white; pennates, shaded

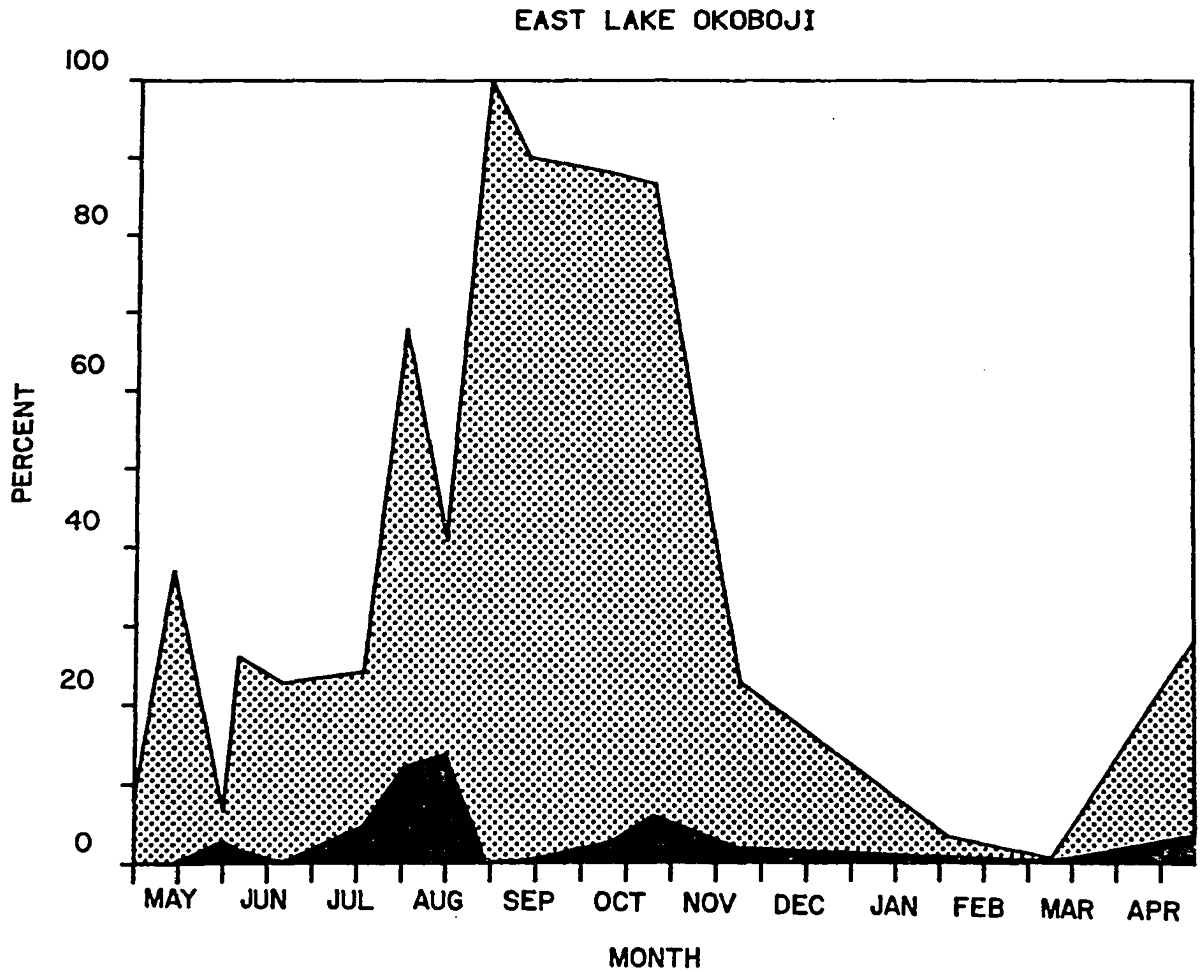

Figure 94. Percent composition of pennate diatom suborders (Hustedt, 1930a) in Lake East Okoboji. Monoraphidineae, black; Biraphidineae, shaded; Araphidineae, white

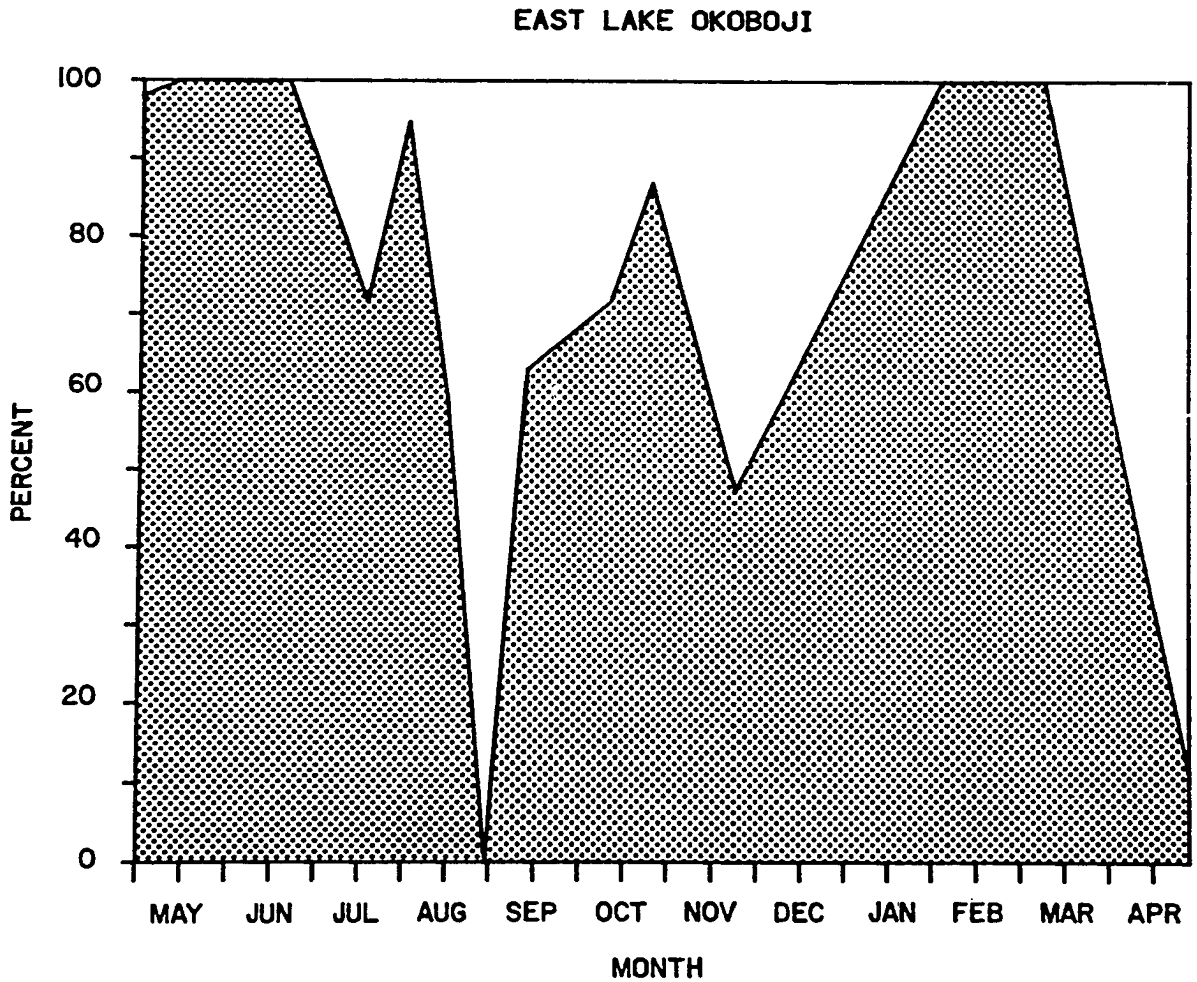

Figure 95. Percent composition of centric diatom subfamilies in Lake East Okoboji. Coscinodiscoideae, shaded; Melosiroideae, white

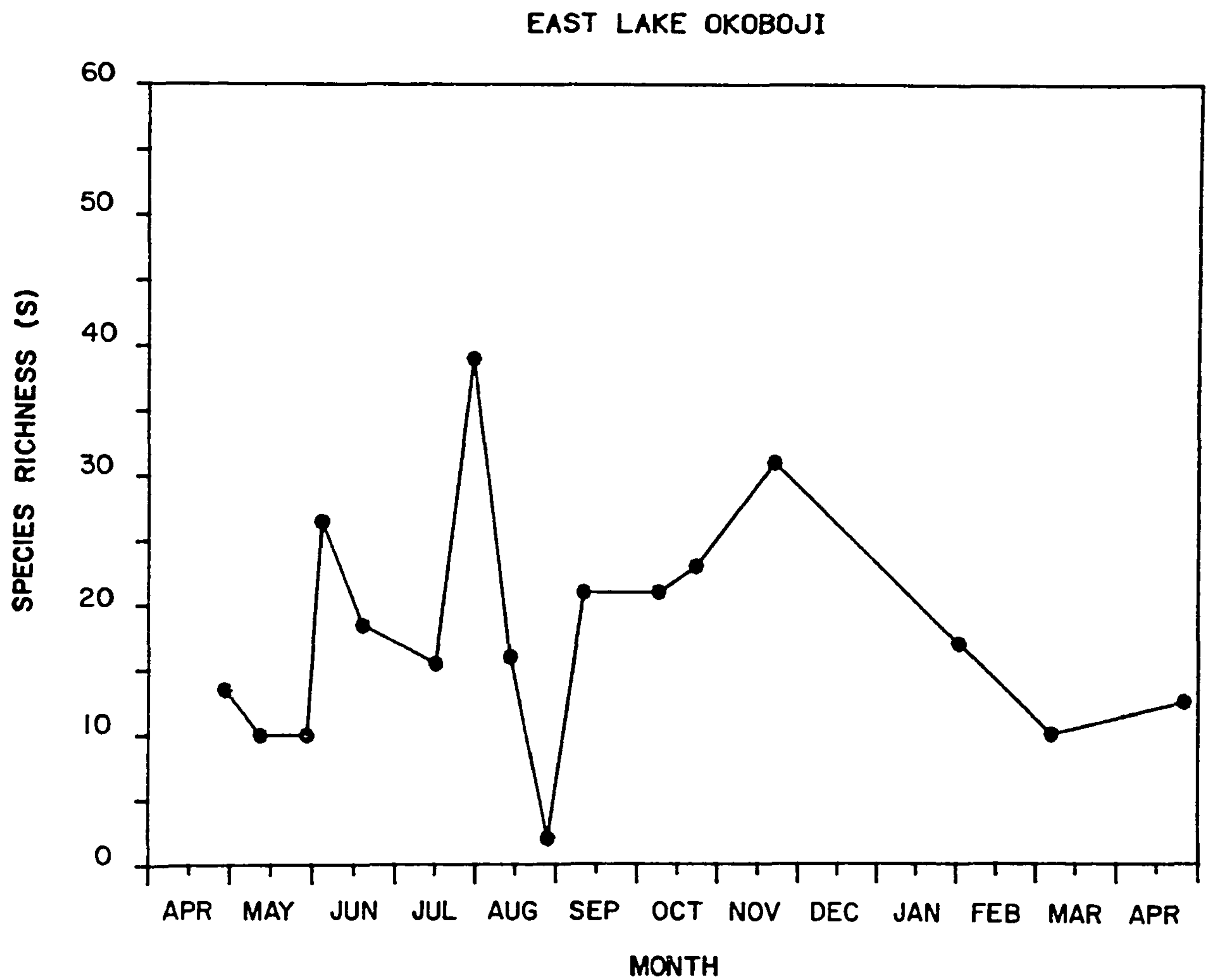

Figure 96. Species richness (S) by sampling date for Lake East Okoboji

crop of diatoms declined in late May, and _Fragilaria capucina_ v. _mesolepta_ was the most abundant species (56%). The diatom standing crop and diversity increased during June (Figure 96), as the centric diatom, _Stephanodiscus hantzschii_ (62 - 72%) pulsed (Figure 93 and 96). _Fragilaria capucina_ v. _mesolepta_ and _Stephanodiscus minutus_ were also common forms. During July, the diatom standing crop again declined, although the number of species recorded reached its maximum for the year (Figure 96) as the planktonic blue-green (Cyanophyta) alga, _Aphanizomenon flos-aquae_, began its "traditional" summer and fall bloom. Common diatoms were _Fragilaria construens_, _Amphora perpusilla_, _Stephanodiscus minutus_, _Nitzschia amphibia_, and _Stephanodiscus hantzschii_. During August, the diversity and abundance of the plankton diatoms declined sharply, reaching the minimum for the year. _Stephanodiscus hantzschii_ and _Melosira granulata_ were replaced by _Nitzschia palea_ as the dominant plankton diatom. _Nitzschia palea_ remained the most abundant species throughout the fall, as the standing crop and the diversity of the plankton diatoms continued to increase (Figure 96). The autumnal diatom pulse was dominated by _Fragilaria capucina_ v. _mesolepta_ (52%), and was characterized by a diverse and abundant flora, as the number of species reached its second highest peak during November. Pennate diatoms continued to predominate under the winter ice, as the number of species declined (Figure 96). *Asterionella formosa* (32 - 65%), *Fragilaria capucina* v. *mesolepta* (14 - 42%), and *Synedra cyclopum* (5 - 37%) were the most common entities. *Stephanodiscus hantzschii* and *Stephanodiscus minutus* are the most abundant centric diatoms. The diversity remained low following the spring turnover, and the pennates, *Synedra cyclopum* and *Fragilaria capucina* v. *mesolepta* became the dominant species.

Center Lake

Community composition The centric and pennate diatoms were generally equally represented in the diatom community of Center Lake (Figure 97). The pennate diatoms occurred with their greatest frequency during the spring and winter months, while the centrics were most abundant during the summer and fall (Figure 97). The Araphidineae and Biraphididineae contributed the greatest number of species to the pennate flora (Figure 98). Members of the Araphidineae were most abundant during the spring, early summer and winter, while the Biraphidineae peaked during the late summer and fall (Figure 98). The Monoraphidineae occurred frequently in the summer and fall samples, but never were a significant component of the plankton (Figure 98). The centric diatom subfamilies Melosiroideae and Coscinodiscoideae occurred with equal frequency in the plankton. Members of the Coscinodiscoideae were most abundant during the spring and early summer, being

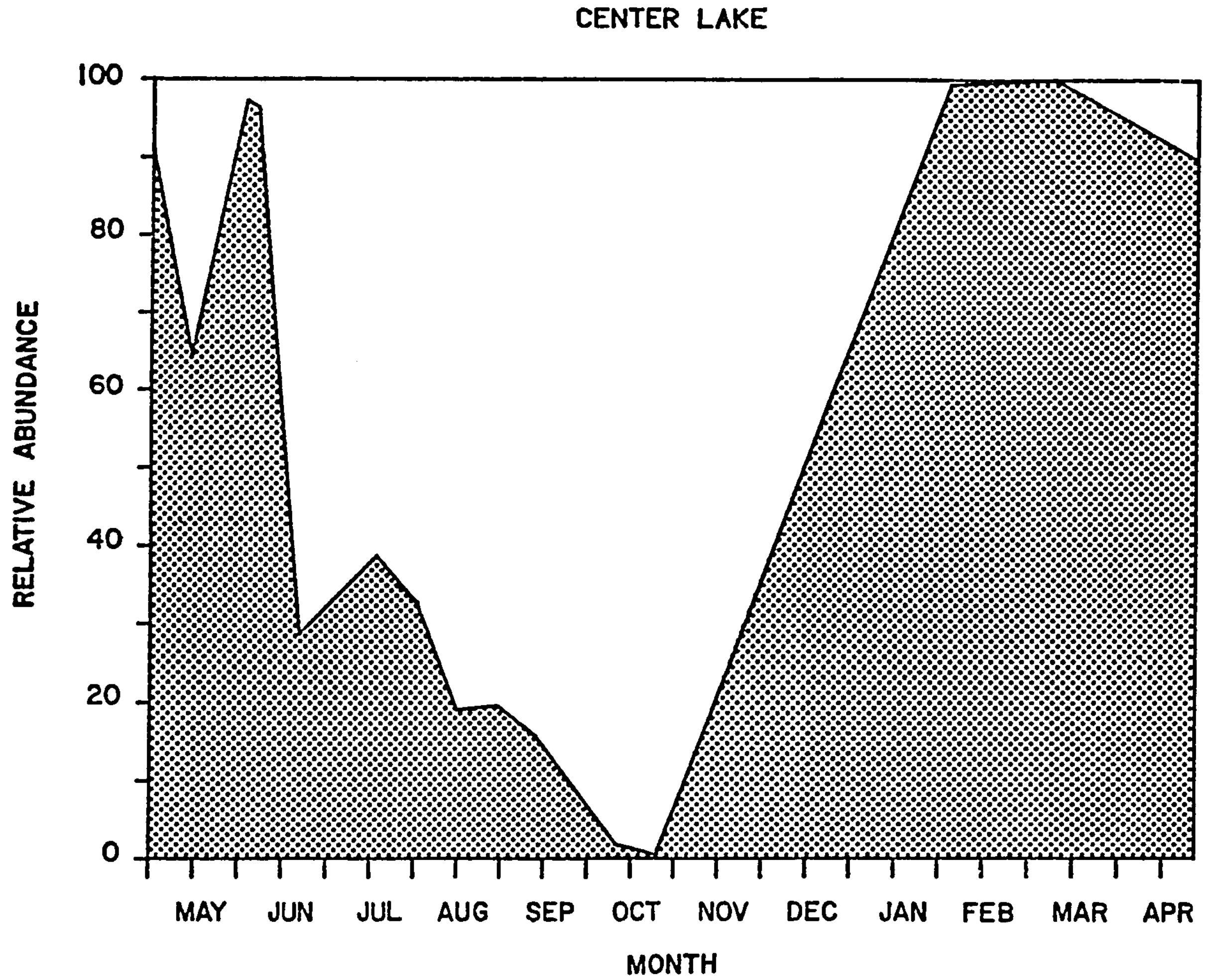

Figure 97. Relative abundance of centric and pennate diatoms in Center Lake. Centrics, white; pennates, shaded

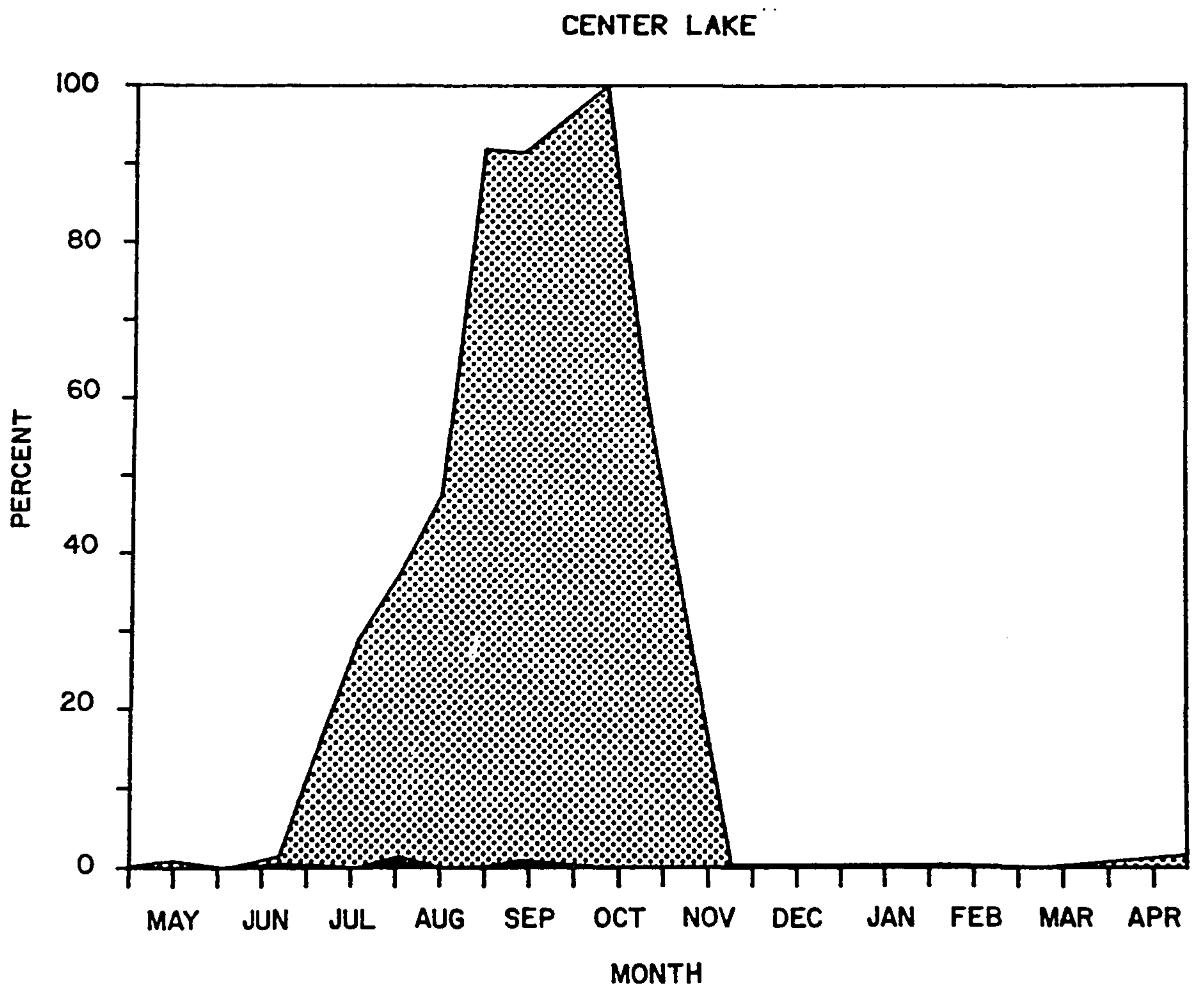

Figure 98. Percent composition of pennate diatom suborders (Hustedt, 1930a) in Center Lake. Monoraphidineae, black; Biraphidineae, shaded; Araphidineae, white

replaced by members of the Melosiroideae during the late summer and fall. The Coscinodiscoideae pulsed during January, but on the whole, the winter and spring samples showed a predominance of species belonging to the Melosiroideae (Figure 99).

Species succession   The vernal maximum was dominated by the pennate diatom, Fragilaria crotonensis (53 - 97%), and exhibited a relatively low diversity of taxa (Figure 100). The centric diatoms Stephanodiscus hantzschii, Stephanodiscus minutus, and Melosira granulata were common throughout the spring. The number of species increased during the summer, and the maximum species diversity for the year occurred in July (Figure 100). Fragilaria crotonensis (6 - 26%), Stephanodiscus niagarae (34% - 14%) and Melosira granulata (24 - 34%) were co-dominants during the early summer. As the abundance of Fragilaria crotonensis declined, the latter species predominated during the remainder of the summer. Melosira granulata dominated the plankton throughout the fall, and Stephanodiscus niagarae became a significant component of the plankton again, during late fall, prior to the winter freeze. The diversity of the diatom flora declined sharply during the late summer, and remained reduced throughout the winter (Figure 100). Asterionella formosa completely dominated the winter plankton, exemplified by the drop in the species richness curve (Figure 100). This taxon

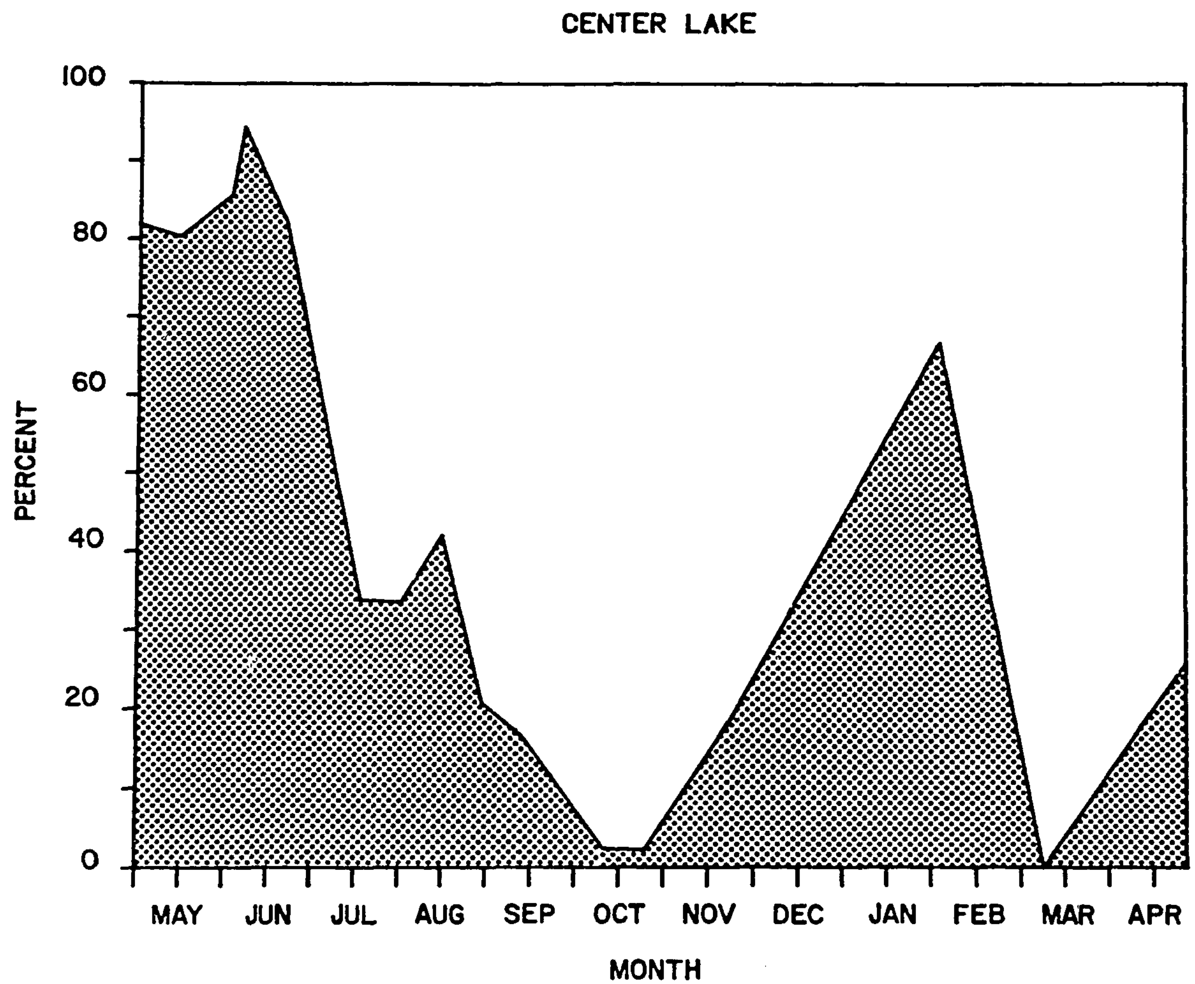

Figure 99. Percent composition of centric diatom subfamilies in Center Lake. Coscinodiscoideae, shaded; Melosiroideae, white

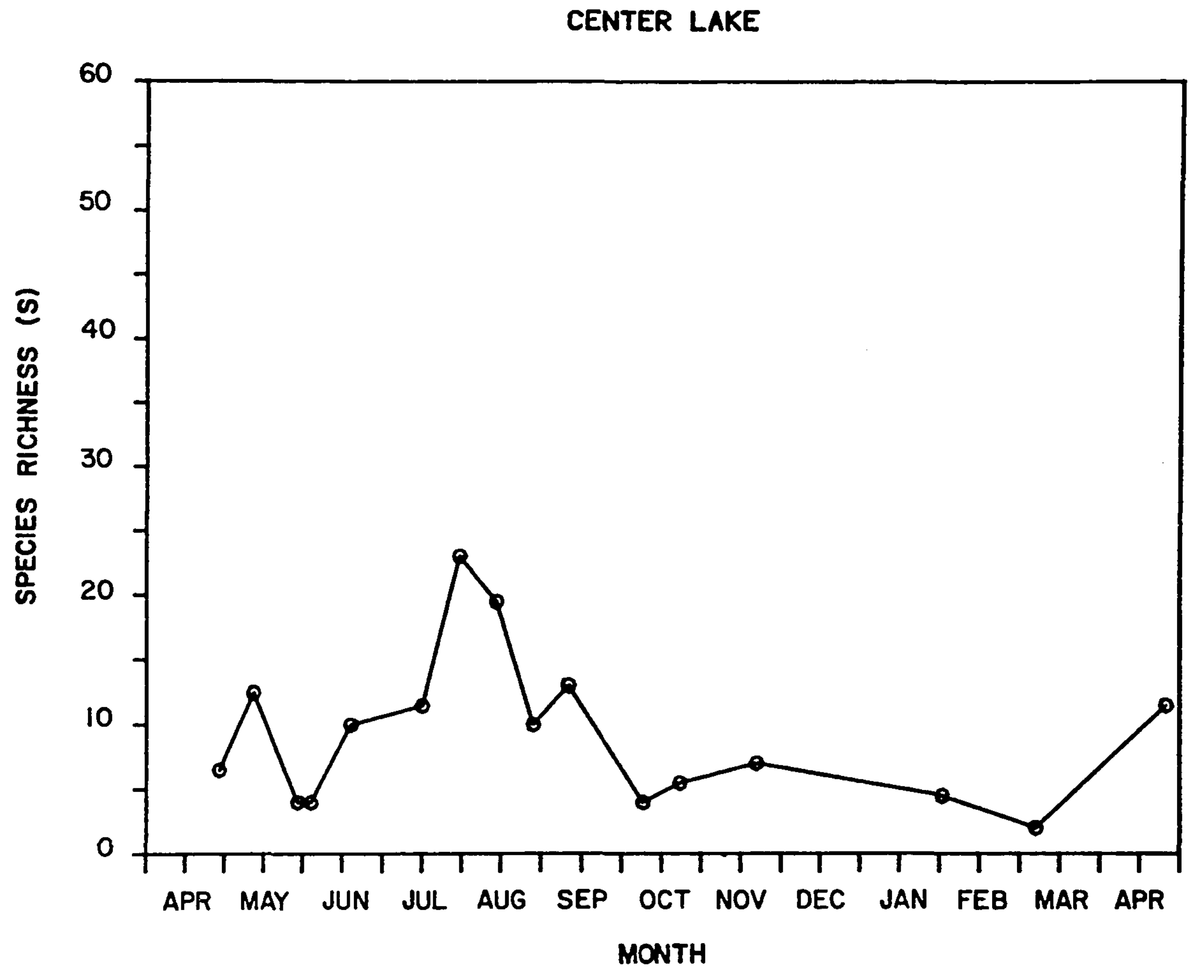

Figure 100. Species richness (S) by sampling date for Center Lake

became a co-dominant with *Fragilaria crotonensis* (42%) and *Fragilaria capucina* v. *mesolepta* (14%) during the spring turnover (April, 1980).

Spirit Lake

Community composition Analysis of the Spirit Lake plankton revealed a predominance of pennate diatoms during the spring, summer, and fall (Figure 101). Members of the Araphidineae were most common during the spring and late winter, while the Biraphidineae were observed with the greatest frequency during the summer and fall (Figure 102). The peak abundance of the Monoraphidineae occurred during mid-winter (Figure 102). The centric diatoms exhibited pulses during the late spring and mid-winter (Figure 101). Members of the Melosiroideae were most frequently encountered during the summer and fall, with the Coscinodiscoideae most abundant during the other seasons (Figure 103).

Species succession The spring diatom maximum exhibited a complex cycle of centric and pennate species. Immediately following the spring turnover (April, 1979), *Stephanodiscus minutus* (81%) dominated the plankton, and *Stephanodiscus hantzschii*, *Stephanodiscus tenuis*, and *Fragilaria capucina* v. *mesolepta* were also present. During early May, *Fragilaria capucina* v. *mesolepta* became the dominant plankter (77%), but was rapidly replaced by *Melosira italica* (81%) during late May. This species remained

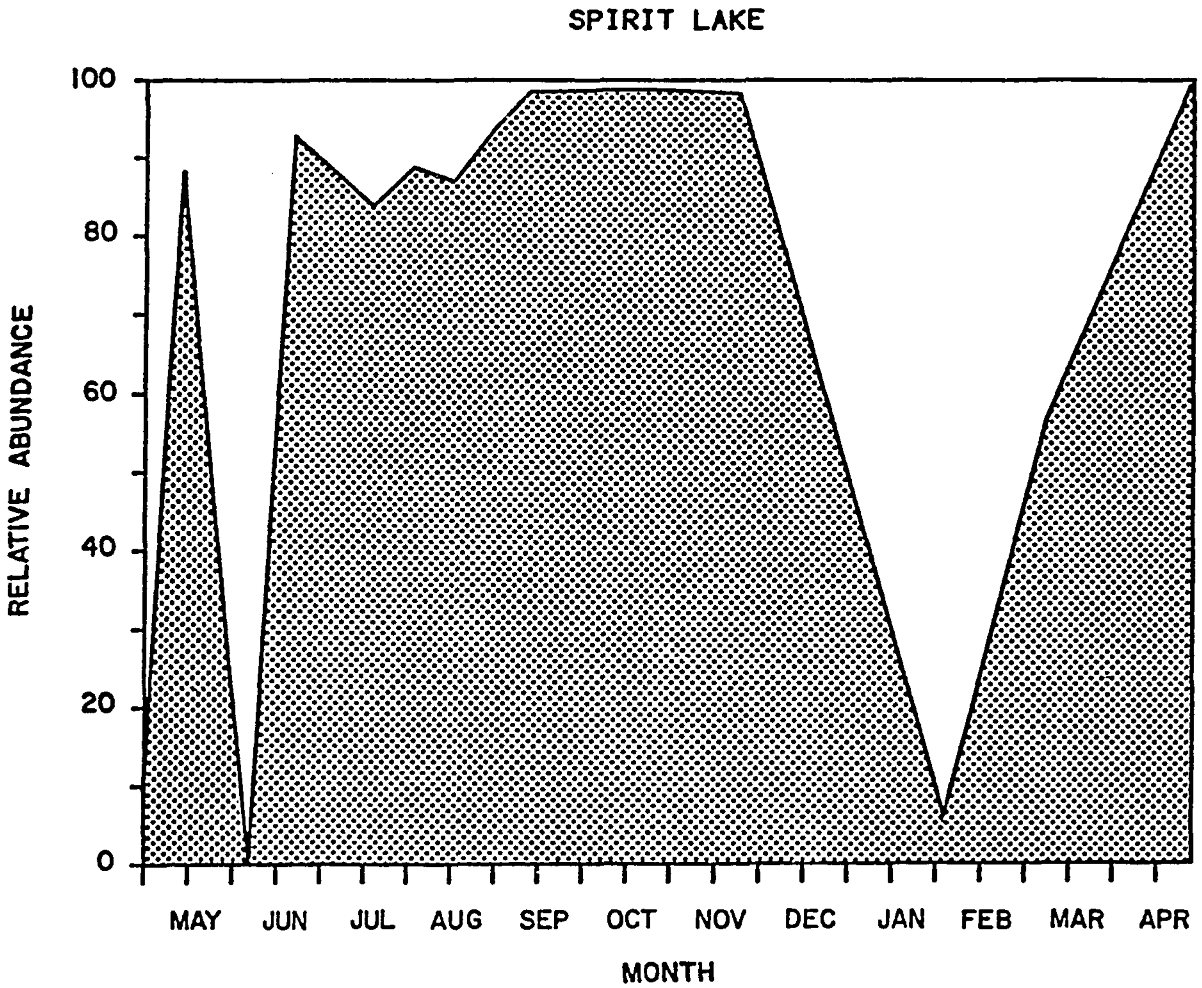

Figure 101. Relative abundance of centric and pennate diatoms in Spirit Lake. Centrics, white; pennates, shaded

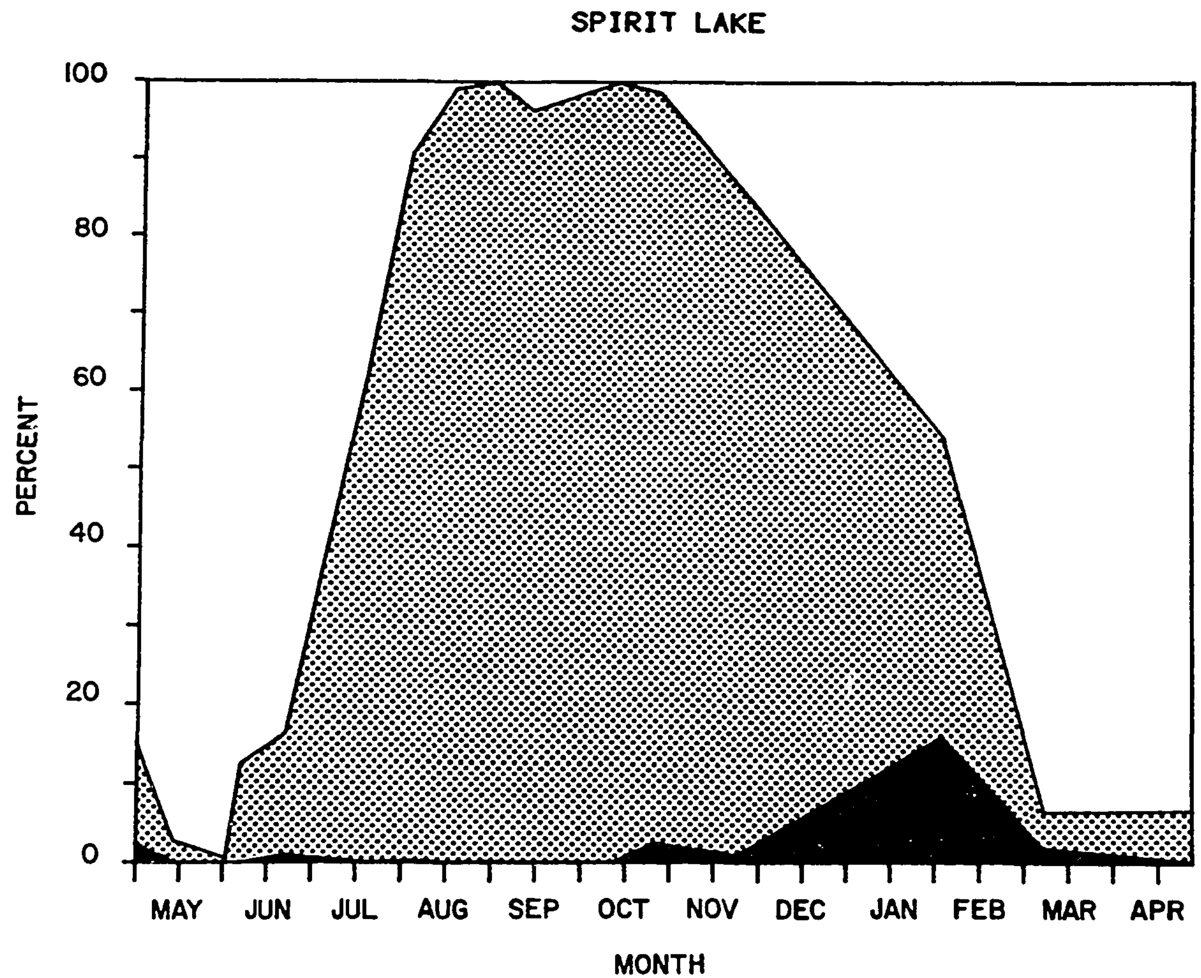

Figure 102. Percent composition of pennate diatom suborders (Hustedt, 1930a) in Spirit Lake. Monoraphidineae, black; Biraphidineae, shaded; Araphidineae, white

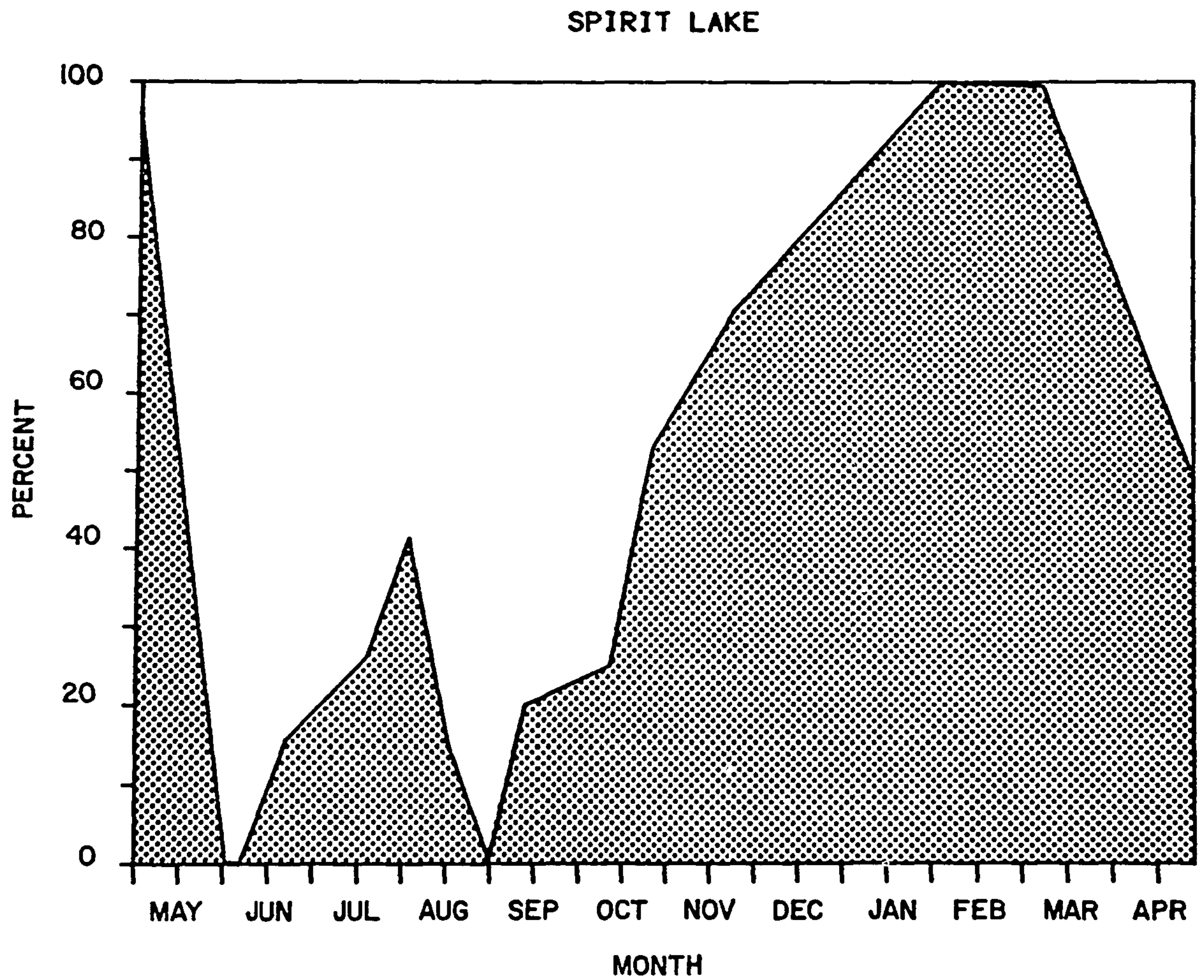

Figure 103. Percent composition of centric diatom subfamilies in Spirit Lake. Coscinodiscoideae, shaded; Melosiroideae, white

dominant through the middle of June. The spring plankton was typified by a few species accounting for the majority of the standing crop, and diversity was corresponding low (Figure 104). The diatoms remained a major component of the summer and fall plankton. During late June, Fragilaria capucina v. mesolepta (60%) pulsed again, as Melosira italica (4%) declined and the diatoms attained their greatest diversity (Figure 104). The pennate diatom, Nitzschia fonticola (51 - 98%), dominated the plankton diatoms throughout the summer and fall. Fragilaria crotonensis and Asterionella formosa were co-dominants during the early summer (June - July), and the centric diatoms, Melosira granulata, Melosira granulata v. angustissima and Stephanodiscus niagarae v. magnifica, were co-dominants during the late summer and the fall. The diversity of the diatom flora declined throughout the summer, reaching a minimum during September (Figure 104). Diversity increased during October, as did the abundance of diatoms. Gomphonema olivaceoides (26%) and Gomphonema olivaceum (26%) became co-dominants with Nitzschia fonticola (24%) during November, as the diversity began to decline (Figure 104). The winter plankton exhibited a pulse of centrics including, Stephanodiscus minutus, Stephanodiscus hantzschii and Stephanodiscus tenuis. During the late winter, pennates replaced the centrics as Asterionalla formosa pulsed. The three Stephanodiscus species remained co-dominants. The

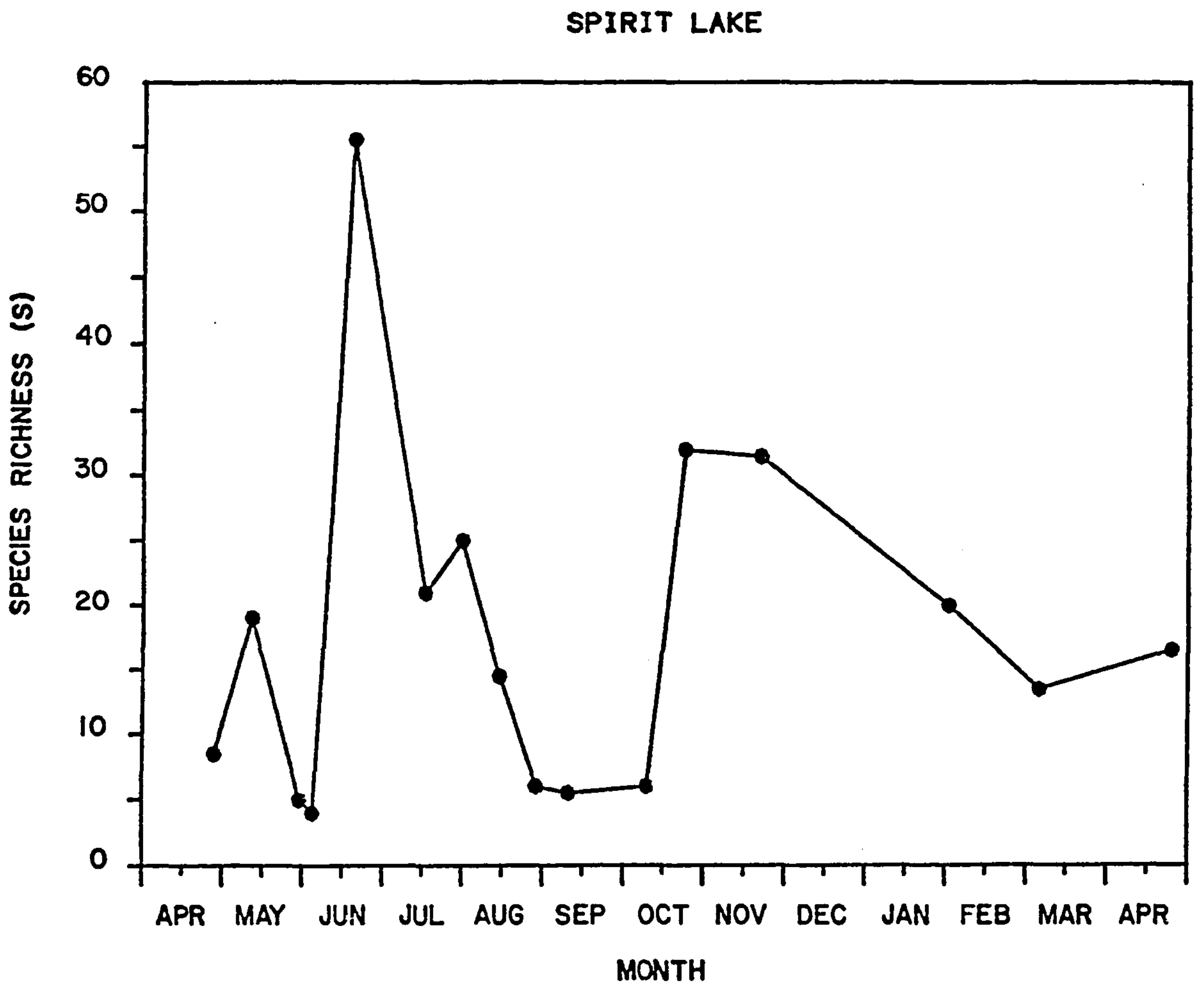

Figure 104. Species richness (S) by sampling date for Spirit Lake

pennate species, Synedra cyclopum (58%), Fragilaria capucina v. mesolepta (18%) and Fragilaria vaucheriae (16%), were the predominant species following the spring turnover (April, 1980).

Silver Lake

Community composition The main trend in the Silver Lake plankton diatom community was a vernal maximum dominated by centric diatoms, with the remainder of the seasons, except for secondary pulses of centrics during the summer and fall, composed predominantly of pennate taxa (Figure 105). Members of the Araphidineae dominated the diatom assemblage during the spring, summer and winter, with species of the Biraphidineae pulsing during the late summer and fall (Figure 106). The Monoraphidineae were frequently encountered in the summer and fall samples, but remained a rare group in the plankton. The centric diatoms were clearly dominated by species belonging to the Coscinodiscoideae, throughout the sampling period (Figure 107). The frequency of occurrence of taxa belonging to the Melosiroideae increased during the summer, fall and early winter, but never accounted for more than 35% of the total centric diatom abundance (Figure 107).

Species succession The spring plankton bloom was characterized by a relatively low species diversity (Figure 108) with the centric diatoms, Stephanodiscus hantzschii, Stephanodiscus minutus and Stephanodiscus tenuis, most

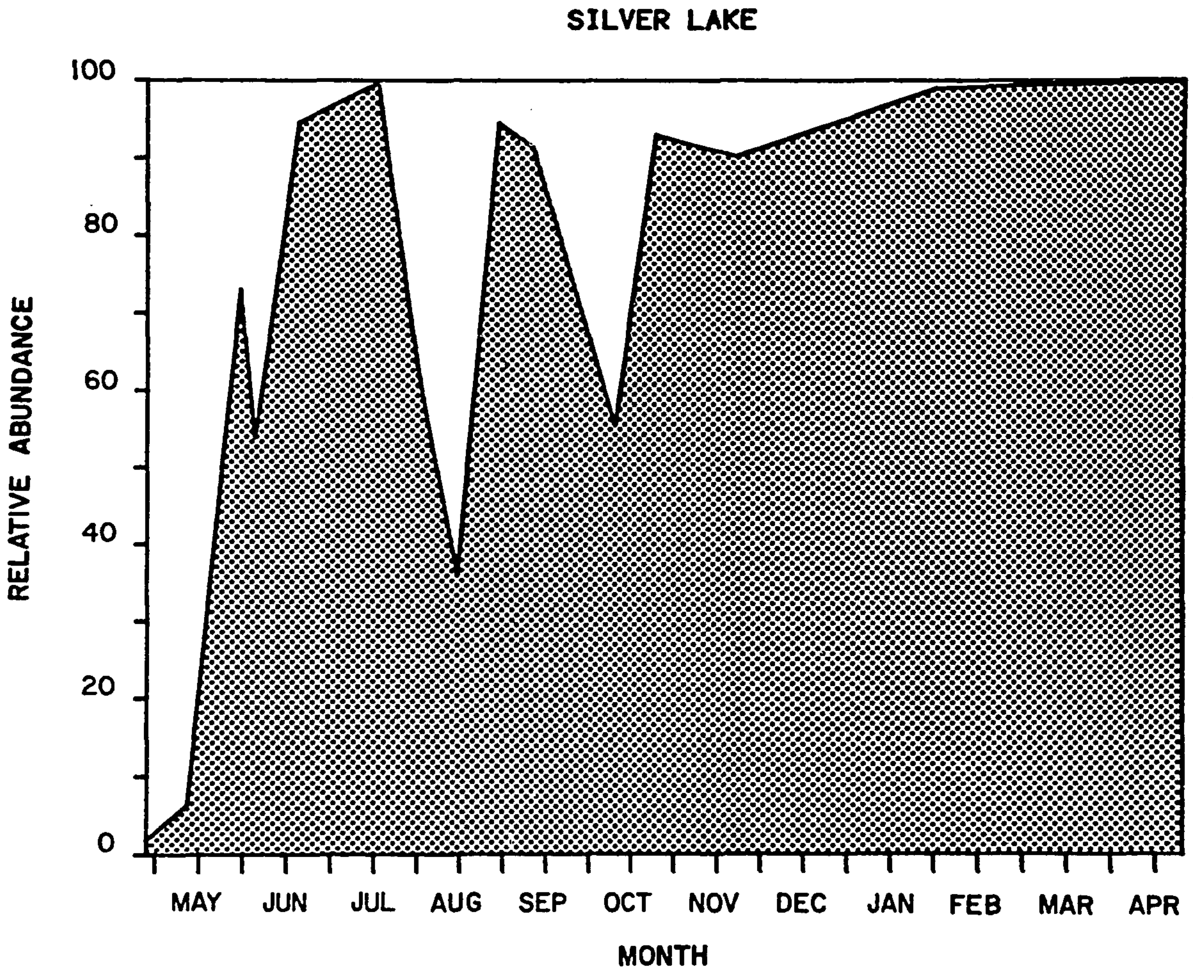

Figure 105. Relative abundance of centric and pennate diatoms in Silver Lake. Centrics, white; pennates, shaded

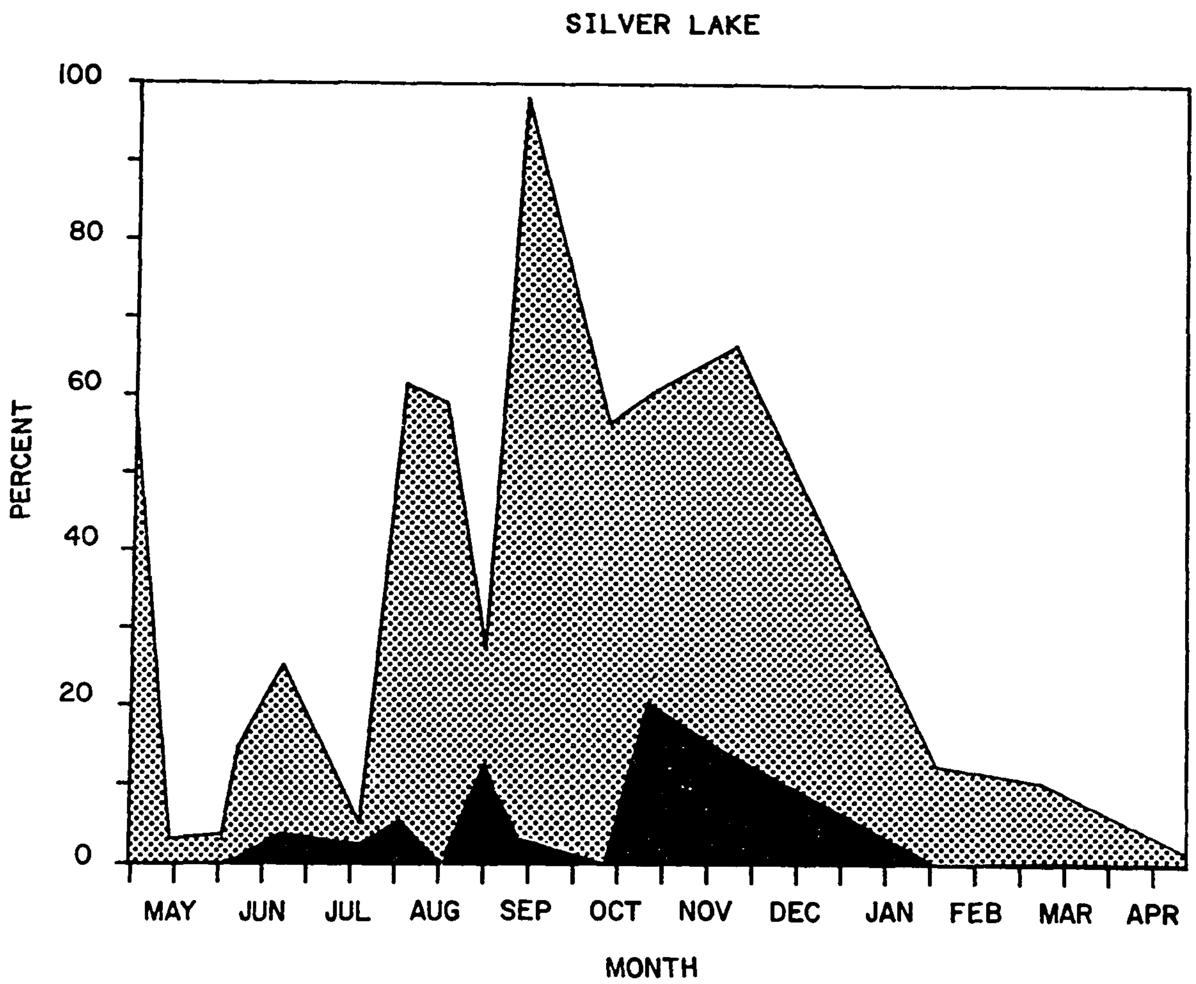

Figure 106. Percent composition of pennate diatom suborders (Hustedt, 1930a) in Silver Lake. Monoraphidineae, black; Biraphidineae, shaded; Araphidineae, white

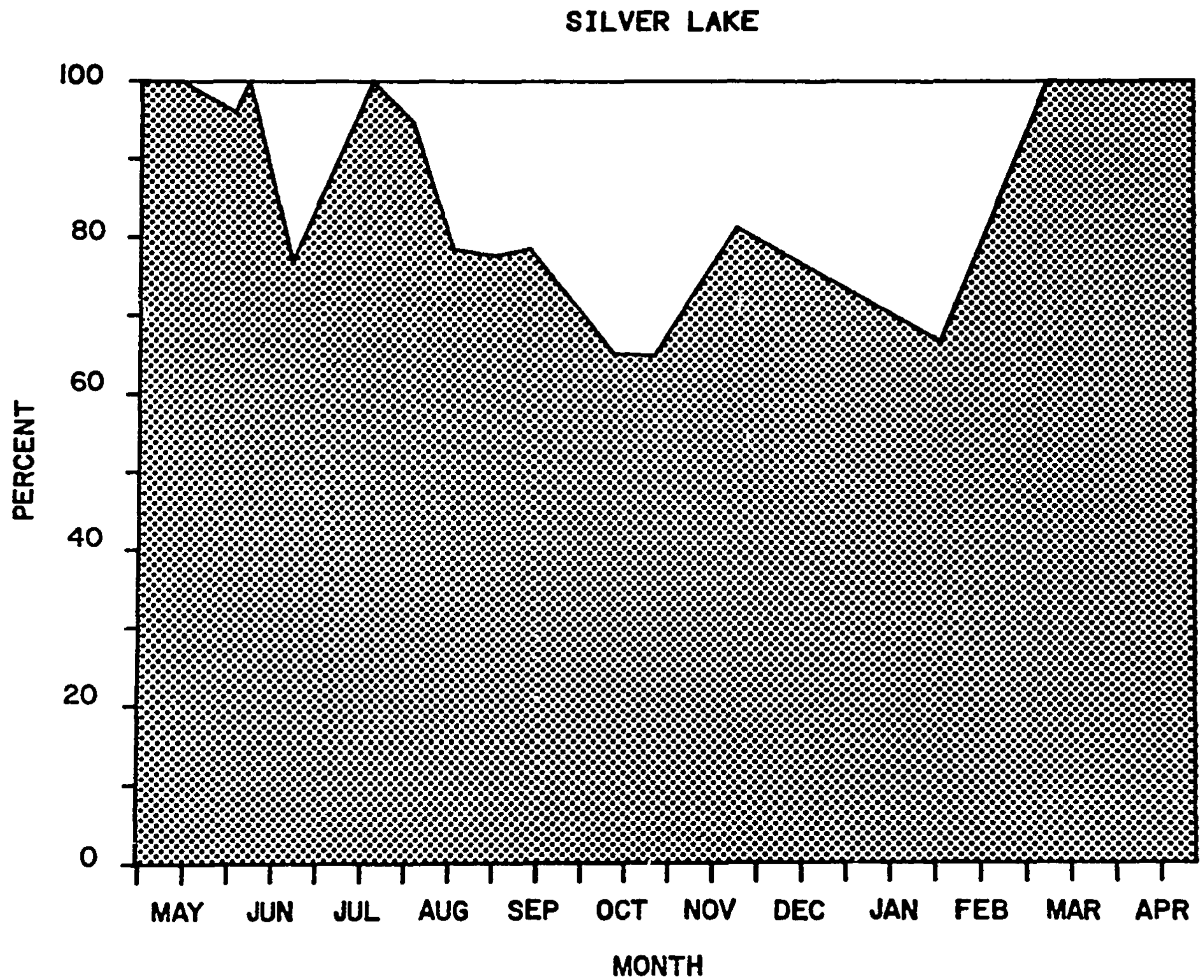

Figure 107. Percent composition of centric diatom subfamilies in Silver Lake. Coscinodiscoideae, shaded; Melosiroideae, white

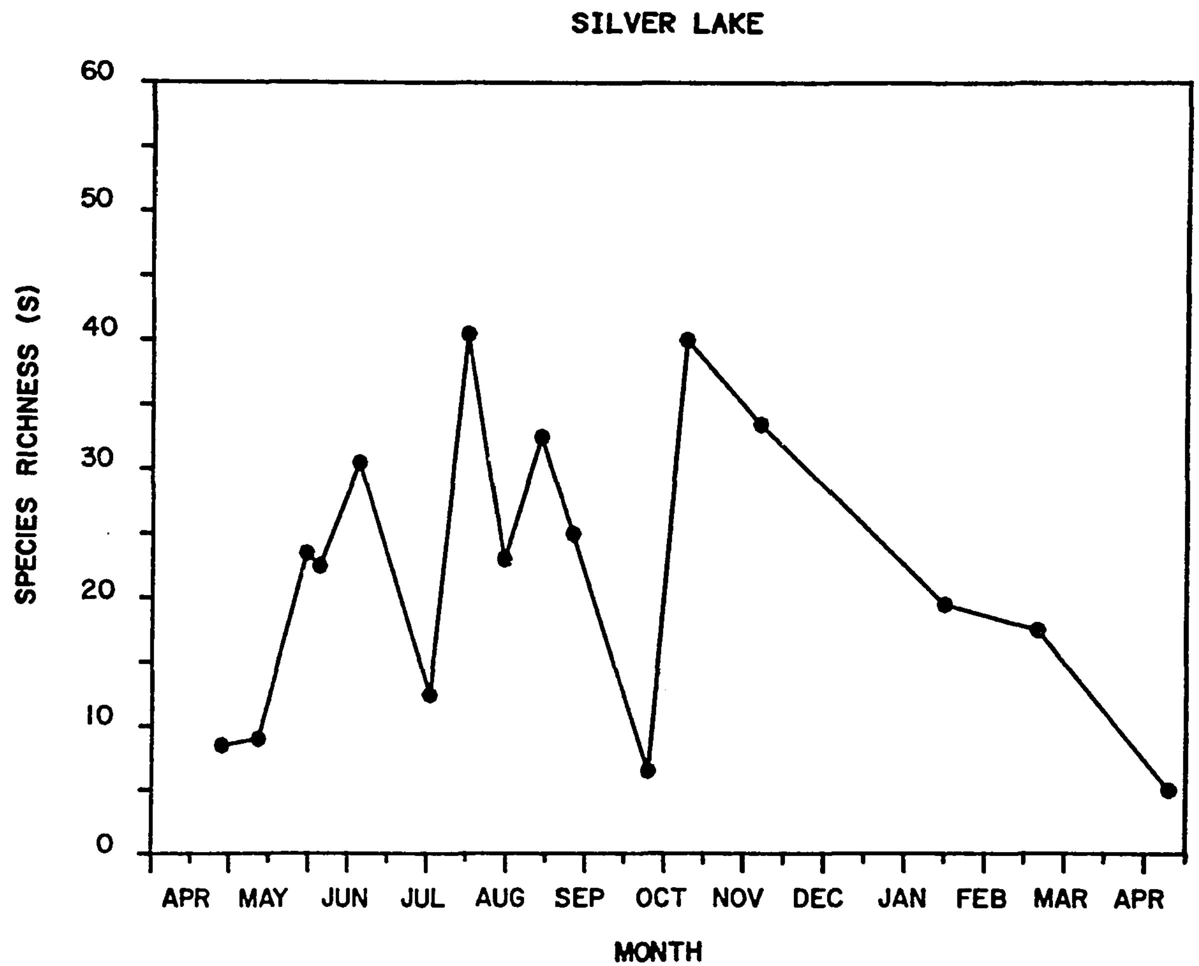

Figure 108. Species richness (S) by sampling date for Silver Lake

prevalent. The centric diatoms declined in importance throughout the spring, as the abundance of the pennates, Fragilaria capucina v. mesolepta, Fragilaria crotonensis and Fragilaria vaucheriae increased during the spring and early summer. The diversity increased markedly during the summer, except for a sharp decline in July, corresponding to a pulse of Fragilaria capucina v. mesolepta. The maximum diversity occurred during late July, and the plankton was characterized by many species, each with a very low abundance. Stephanodiscus niagarae, Stephanodiscus hantzschii, Surirella biseriata f. punctata, and Fragilaria construens were common entities. This also marked the beginning of the annual Aphanizomenon flos-aquae (Cyanophyta) bloom, which persisted throughout the summer and fall. Concomitant with the bloom of Aphanizomenon, Nitzschia palea, Nitzschia amphibia, Melosira granulata and Stephanodiscus niagarae were the most important diatom taxa. Fragilaria capucina v. mesolepta pulsed during late August. This species continued to increase in abundance throughout the late fall, as did Fragilaria capucina, and they dominated the plankton assemblage for the remainder of the study period. I did not observe an autumnal pulse of diatoms, as typically occurred in the other lakes. However, there was a marked increase in the abundance of Fragilaria capucina v. mesolepta and Fragilaria capucina under the winter ice.

The Nature of the Plankton Diatom Communities

Comparisons of the floras

The plankton diatom flora of the Region was characterized by an abundance of pennate taxa (Figure 109). Species of the Araphidineae showed the greatest relative abundance in the plankton, with *Fragilaria capucina*, *F. capucina* v. *mesolepta*, *F. crotonensis*, and *Asterionella formosa* being the most frequently encountered species. Spirit Lake was the only lake in which the contribution of the Biraphidineae to the plankton standing crop exceeded that of the Araphidineae (Figure 109). This was due to the almost complete dominance of the summer diatom plankton by *Nitzschia fonticola*.

The centric diatoms were the second most abundant diatom group (Figure 109) in the Lake District. Members of the subfamily Coscinodiscineae were the most common taxa encountered, except in Spirit and Center lakes, where species of the subfamily Melosiroideae were of equal importance (Figure 109). *Stephanodiscus tenuis*, *Stephanodiscus minutus*, *Stephanodiscus hantzchii*, *Stephanodiscus niagarae*, *Melosira granulata* and *Melosira granulata* v. *angustissima* were the most common taxa.

From the previous discussions of the occurrence, distribution, and periodicity of the plankton diatoms, it becomes increasing clear that, while the dominant species varied spatially and temporally within each lake, the species

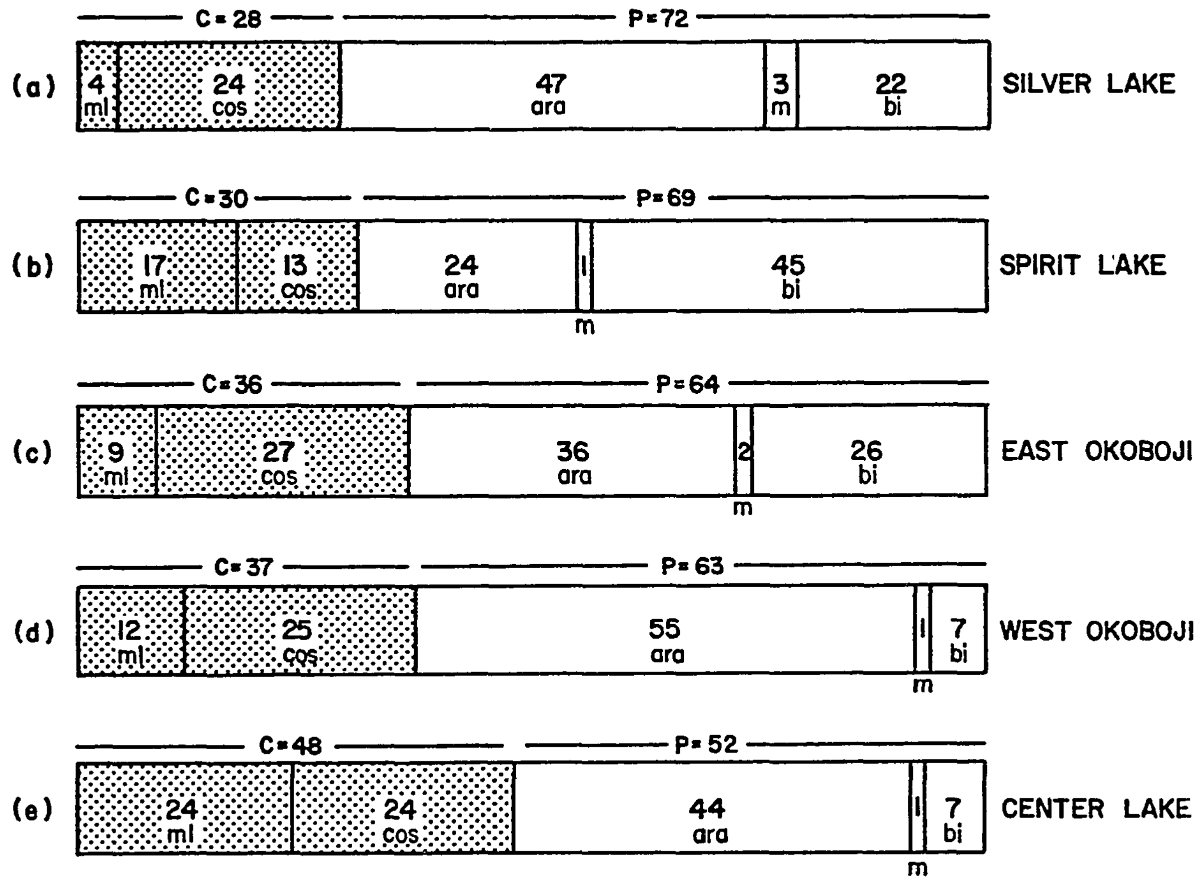

Figure 109. Percent relative abundance of major diatom groups in the plankton of the study lakes. Centrics, c; pennates, p; Melosiroideae, ml; Coscinodiscoideae, cos; Araphidineae, ara; Monoraphidineae, m; Biraphidineae, bi

varied spatially and temporally within each lake, the species present in the floras were remarkably similar. This observation is supported by a cluster analysis of the lakes across taxa, when the abundances for the diatom taxa were reduced to presence/absence notation (Figure 110). The cluster dendrogram for lakes showed that with regard to the diatom taxa present, lakes East and West Okoboji were the most similar, followed by Silver Lake, Center Lake, and Spirit Lake. Spirit Lake and Lake East Okoboji were the most dissimilar. The dissimilarity between all of the lakes was small, however, as indicated by the high level of similarity (>60%) for the entire dendrogram (Figure 110). If, however, the lakes were classified using the relative abundance data, a different pattern emerged (Figure 111). Lakes West and East Okoboji had the most similar plankton diatom assemblages, while Silver Lake, Spirit Lake, and Center Lake all stood alone. Taken as a whole, the composition of the diatom assemblages were quite dissimilar (Figure 111).

Origins of the plankton diatoms

Very few diatom species have been shown to be truly euplanktonic, i.e., permanently planktonic throughout the organisms entire life history. Hutchinson (1967) suggested that the majority of the algal species that biologists associate with the plankton should be more correctly classified as meroplankton, i.e., organisms planktonic only at

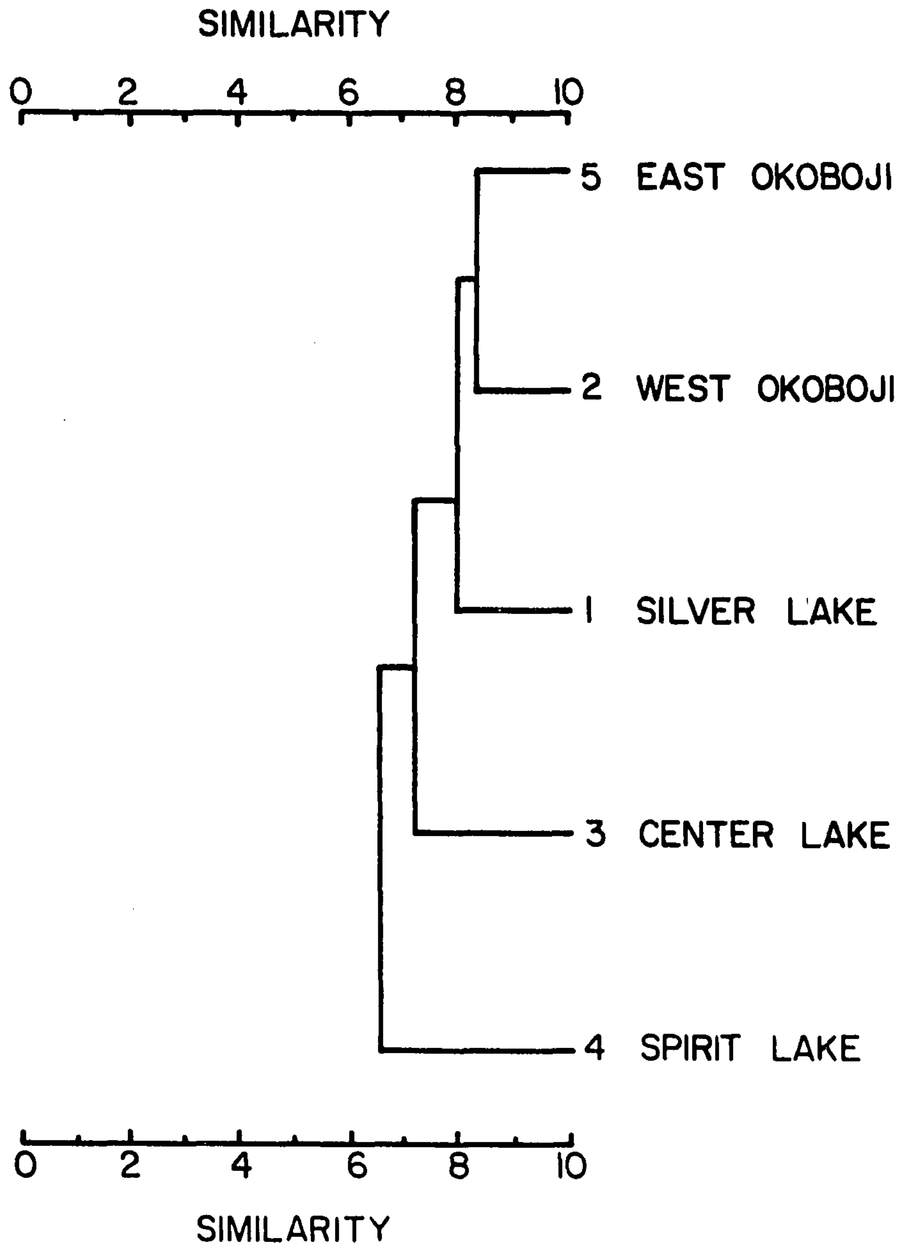

Figure 110. Dendrogram of the cluster analysis by lakes, using 28 diatom taxa which occurred at a frequency of $\geq$ 5% as variables. Frequency data was reduced to presence/absence notation for the analysis

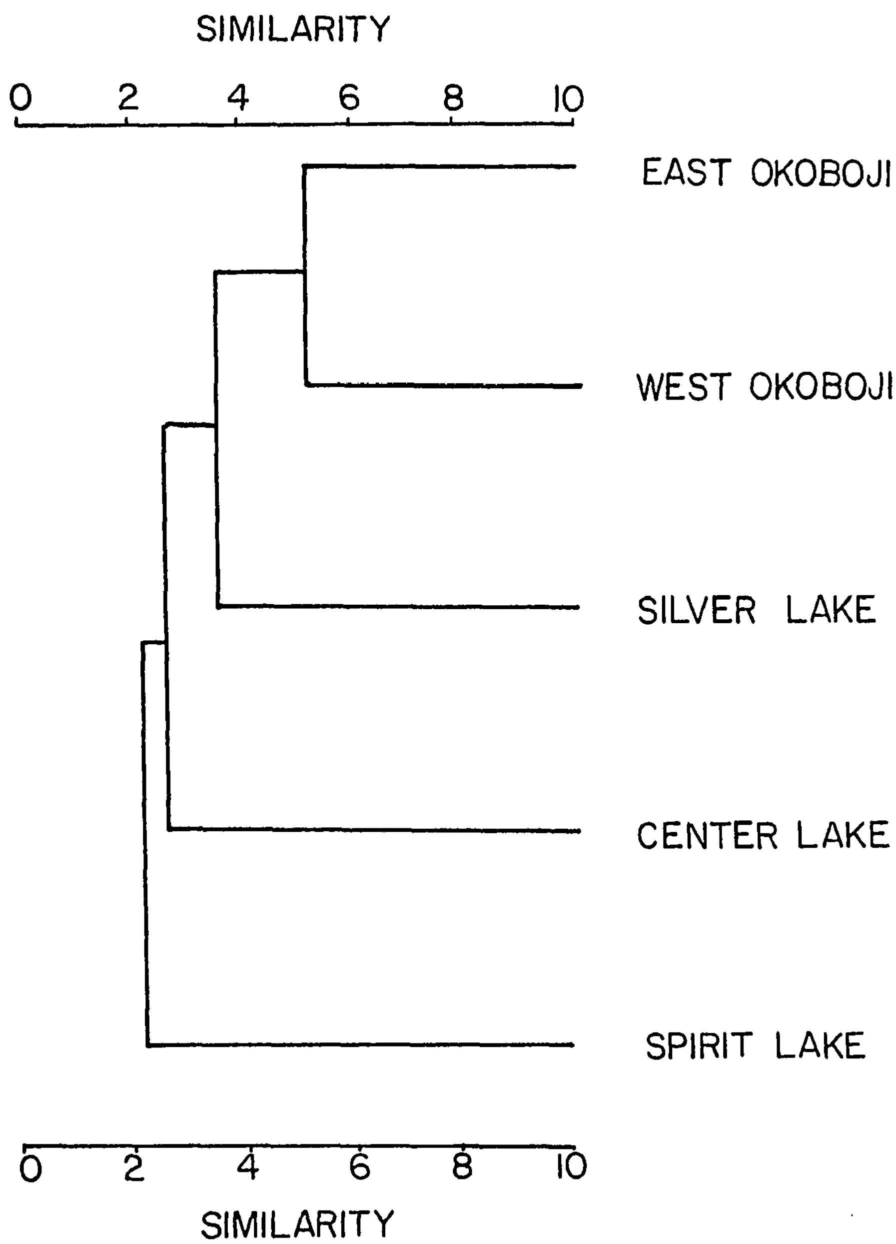

Figure 111. Dendogram of the cluster analysis by lakes, using 28 diatom taxa which occurred at a frequency of $\geq$ 5% as variables. Frequency data was used for the analysis

certain times in their life histories. Many of the species present in plankton collections are of littoral/benthic origin (Patrick and Reimer, 1966) and are only accidentally associated with the plankton, i.e., pseudoplankton (Hutchinson, 1967). Of the 248 diatom taxa I identified from the Lake District, only one species, *Asterionella formosa*, was euplanktonic; 21 species were meroplanktonic (Table 254); and 226 were pseudoplanktonic.

In looking at the distribution and occurrences of meroplankton and pseudoplankton within the lakes, some interesting patterns emerged. There were, on the yearly average, two to three times as many species of pseudoplankton per sampling date as meroplanktonic forms (Figures 112 - 116). The pseudoplankton generally dominated the plankton, with respect to the number of species, except during the early spring following ice break-up and the spring turnover. The only exception to these observations was Center Lake which showed a greater number of species of meroplanktonic forms throughout the year (Figure 114). On the average there were twice as many species of meroplankton in this lake at any given time. The relative abundance of these two groups was in direct contrast to the observed patterns for the number of taxa. The plankton of all of the lakes was dominated by meroplanktonic forms (Figure 117). Spirit Lake, Lake East Okoboji, and Silver Lake were the only lakes in which the

Table 254. List of meroplanktonic diatom taxa collected from the Lake District

Cyclotella bodanica	*Melosira ambigua*
Cyclotella comta	*Melosira granulata*
Cyclotella meneghiana	*Melosira granulata* v. *angustissima*
Cyclotella michiganiana	
Cyclotella stelligera	*Melosira islandica*
Cyclotella striata	*Melosira italica*
Fragilaria capucina	*Melosira varians*
Fragilaria capucina v. *mesolepta*	*Stephanodiscus hantzschii*
Fragilaria crotonensis	*Stephanodiscus minutus*
Fragilaria crotonensis v. *oregona*	*Stephanodiscus niagarae*
Synedra cyclopum	*Stephanodiscus niagarae* v. *magnifica*
Synedra cyclopum v. *robustii*	
	Stephanodiscus tenuis

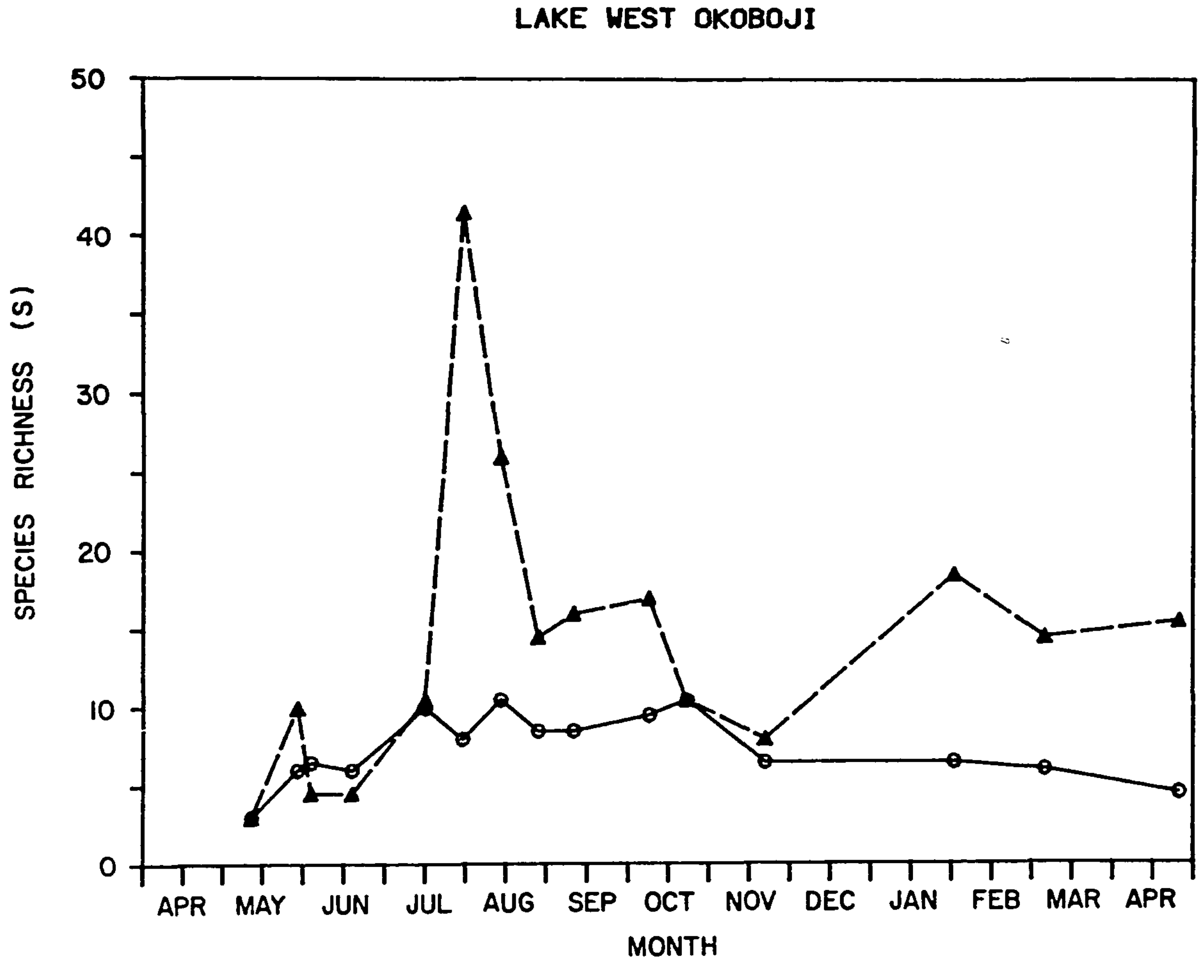

Figure 112. Number of species of meroplanktonic (O——O) and littoral/benthic (▲--▲) diatoms that occurred in the plankton of Lake West Okoboji

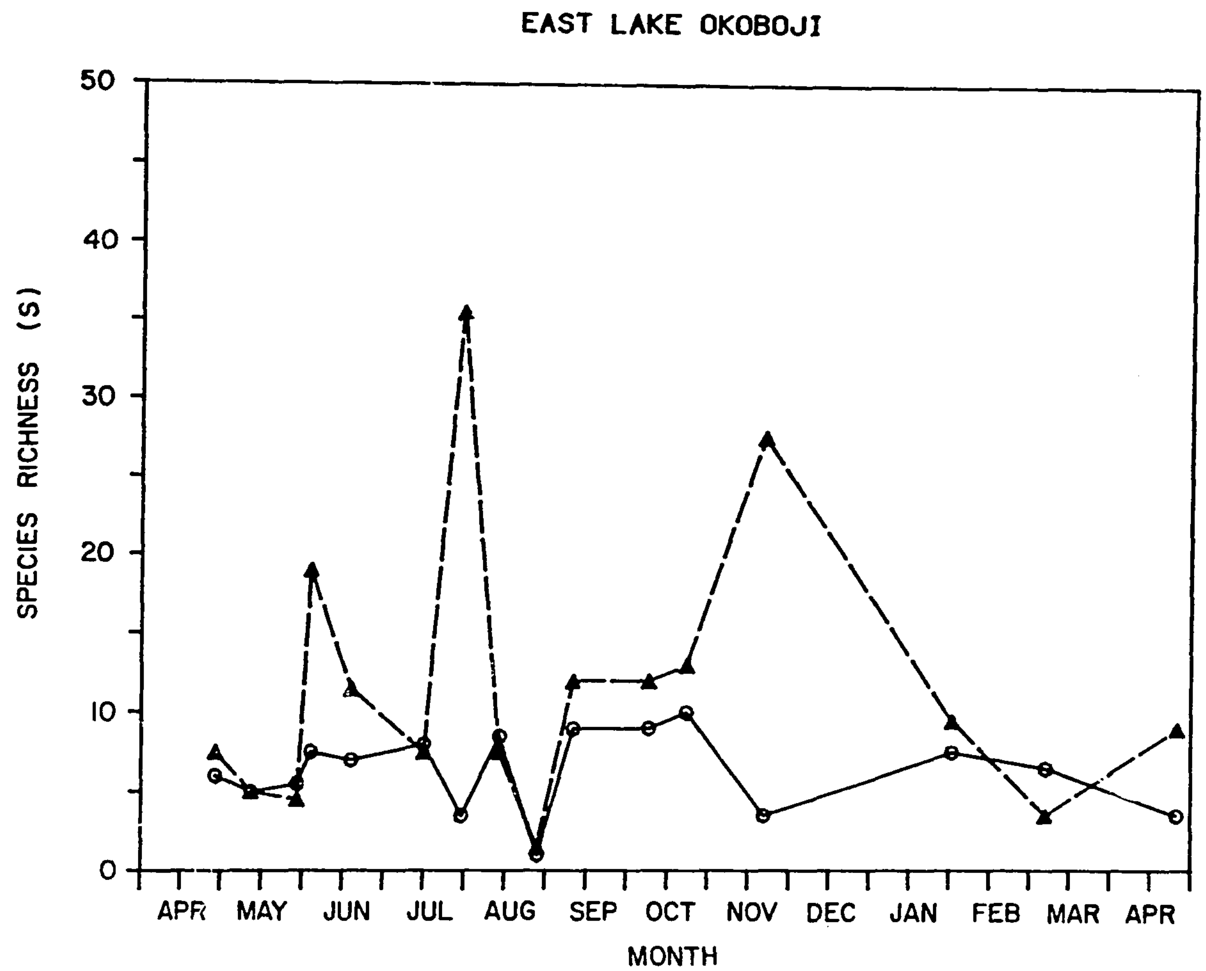

Figure 113. Number of species of meroplanktonic (O——O) and littoral/benthic (▲- -▲) diatoms that occurred in the plankton of Lake East Okoboji

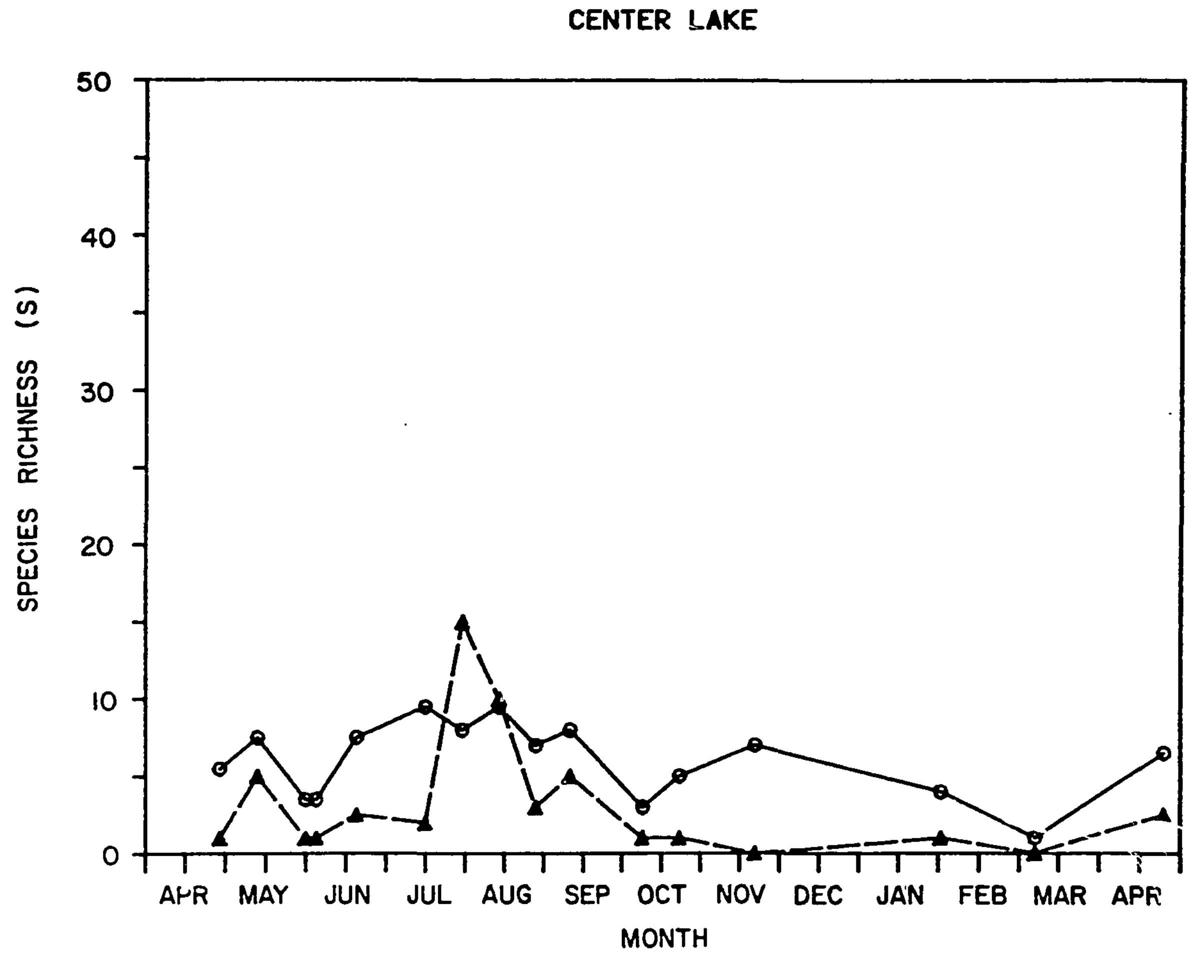

Figure 114. Number of species of meroplanktonic (O——O) and littoral/benthic (▲- -▲) diatoms that occurred in the plankton of Center Lake

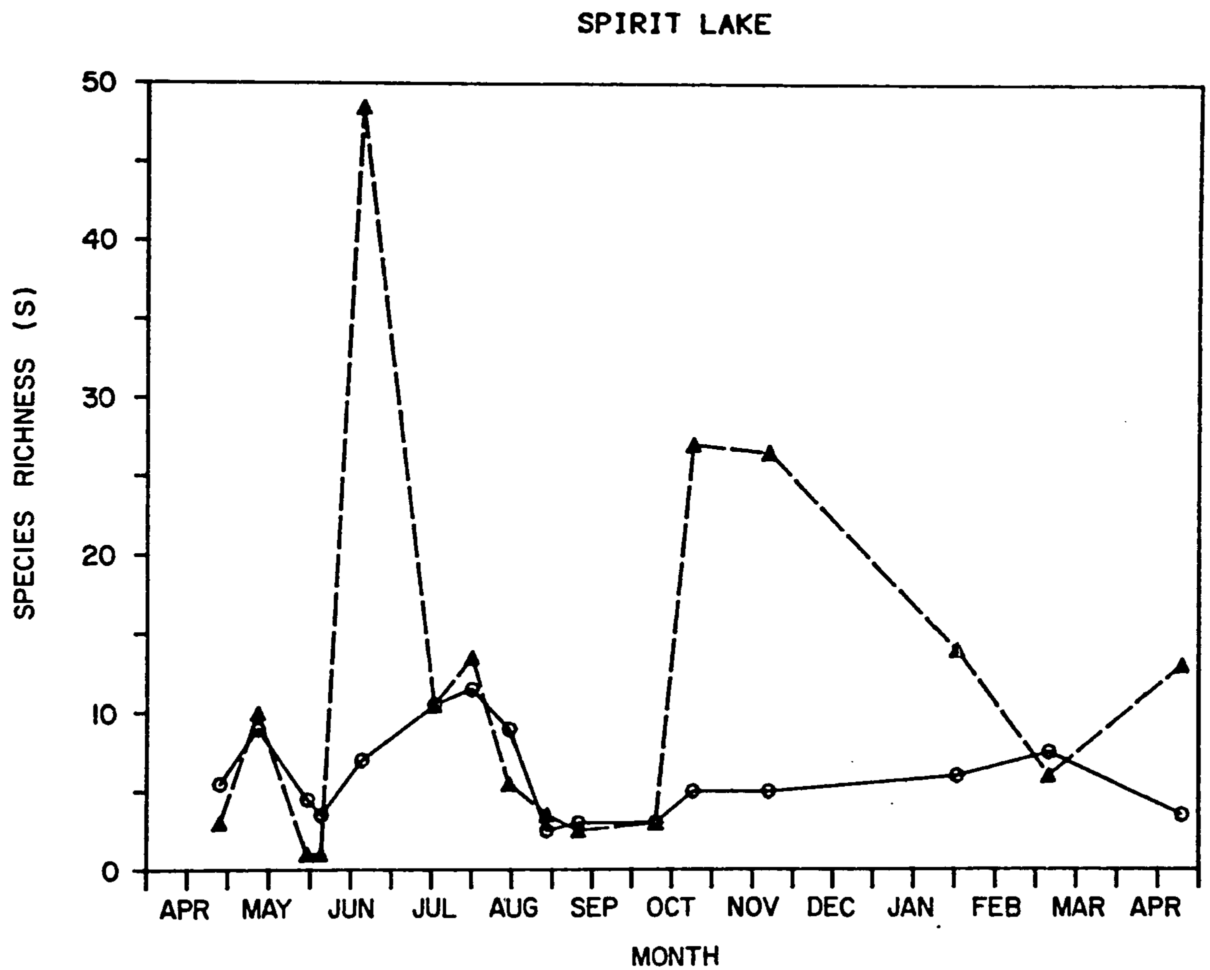

Figure 115. Number of species of meroplanktonic (O——O) and littoral/benthic (▲- -▲) diatoms that occurred in the plankton of Spirit Lake

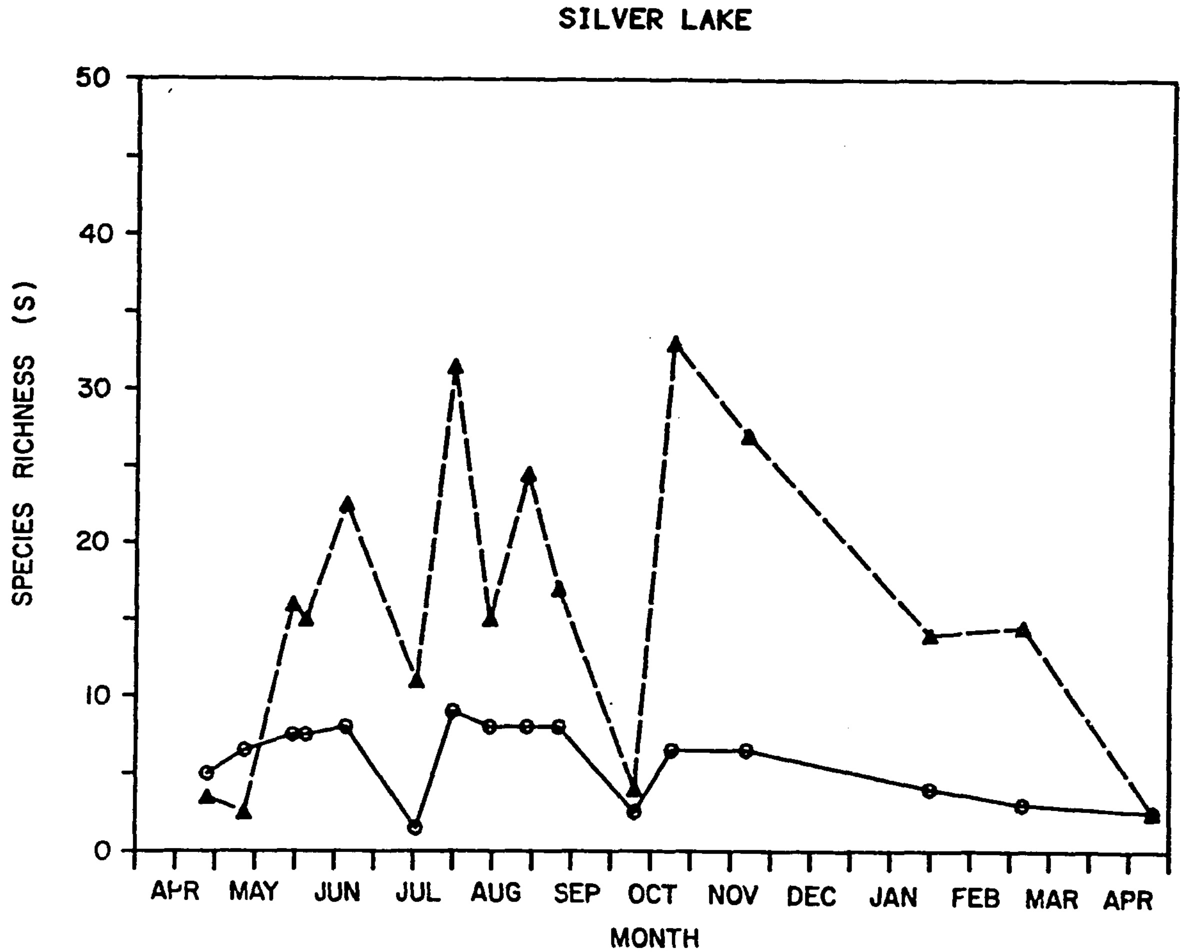

Figure 116. Number of species of meroplanktonic (O——O) and littoral/benthic (▲- -▲) diatoms that occurred in the plankton of Silver Lake

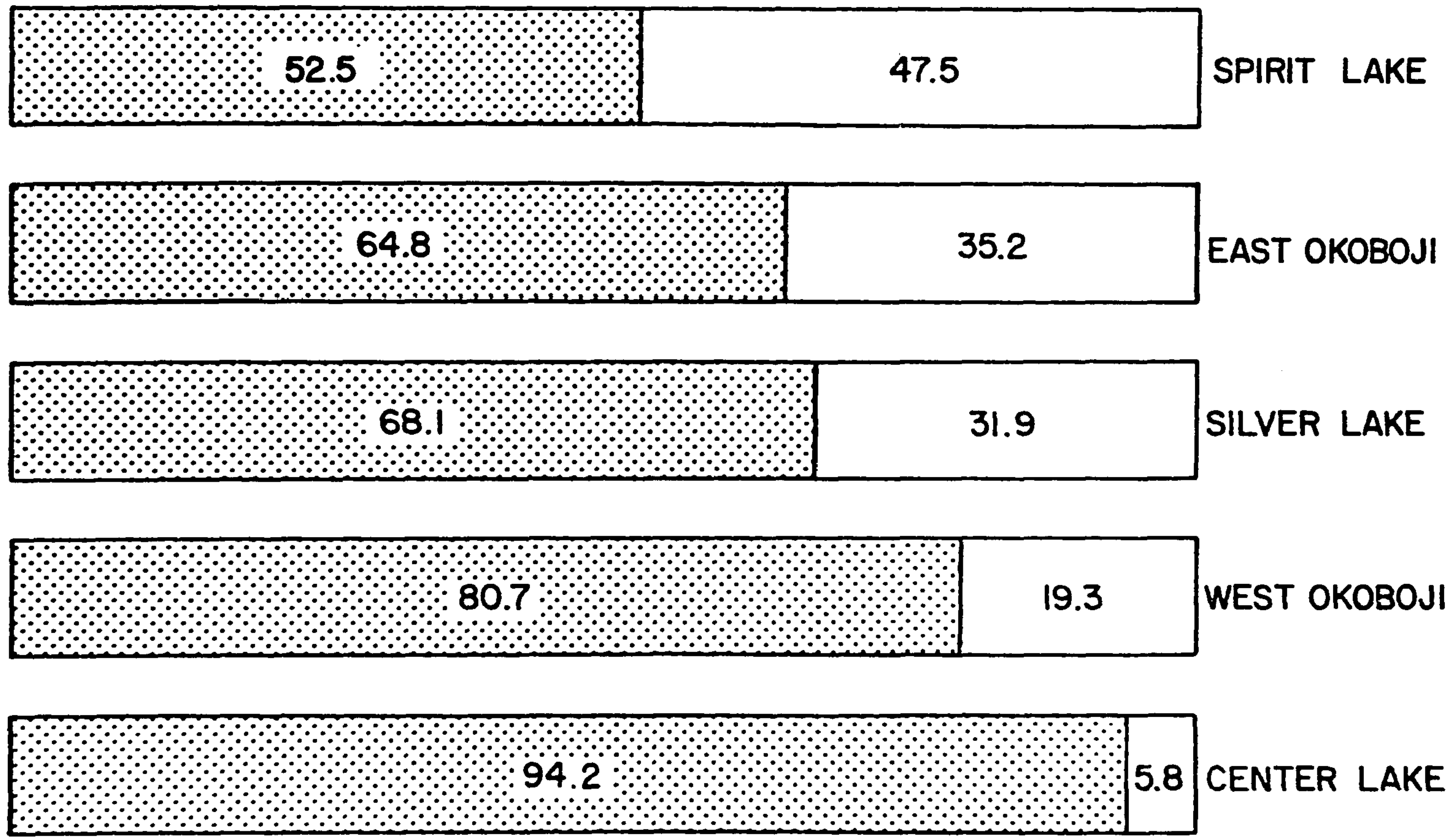

Figure 117. Relative abundance of diatoms from the plankton of the study lakes. Shaded, meroplanktonic forms; white, littoral/benthic forms

pseudoplankton contributed significantly to the plankton standing crop.

Why is it that some lakes in the Region had a greater abundance of littoral/benthic diatoms than others? The most plausible explanation appears to be that the increased abundance of littoral forms was related to the interaction of basin morphometry and the prevailing winds. The evidence which points to this is the increase in the number of species of benthic forms in the plankton during the warmer months of the year (Figure 112 - 116), and their subsequent decline during periods of ice cover. Ice cover obviously is a barrier to wind mixing of the lakes and prevents wave action and deep mixing of the surface waters which would tend to suspend littoral and benthic diatoms in the open water. In addition, the upward growth of submerged macrophytes into the photic zone during the spring and summer, creates new substrates for littoral taxa and increases the likelihood that these forms will be detached by water currents and introduced into the plankton. One would expect then, that there would be a positive correlation between the extent of littoral development (defined here as the extent of lake bottom exposed to $\geq$1% of the incident solar radiation received at the lake's surface) and the diversity and abundance of pseudoplanktonic diatoms in the plankton. To investigate this relationship I first estimated the depth corresponding to the 1% level of incident surface light within each lake, based on submersible photometer readings for lakes East and West Okoboji and the Gar lakes (Bachmann and Jones, 1974), and secchi depth readings within all of the lakes (Bachmann et al., 1980). The aerial extent of lake bottom existing above this depth was calculated and expressed as a percentage of the total lake surface area. Estimates of percent littoral development for the study lakes are: Center Lake, 26%; Lake West Okoboji, 35%; Lake East Okoboji, 56%; Spirit Lake, 75%; and Silver Lake, 90%. The mean annual abundance of pseudoplanktonic entities (including species of the Araphidineae, Biraphidineae, and Monoraphidineae) were plotted as a function of the percent littoral development for each lake. The relationship was positive and highly significant ($r^2 = 0.63$, $P = 0.005$) (Figure 118).

Ecological Classification of Plankton Diatoms

Perhaps the most important question that can be asked about the Lake District is whether water quality is improving or continuing to decline. Stoermer (1963a) showed through his analysis of the fossil diatom flora of Lake West Okoboji, that this lake had "evolved" to a mesotrophic-eutrophic state long before man's activities began in the basin. Cultural development has only intensified this natural trend throughout the Region, and the recent changes in the water quality have

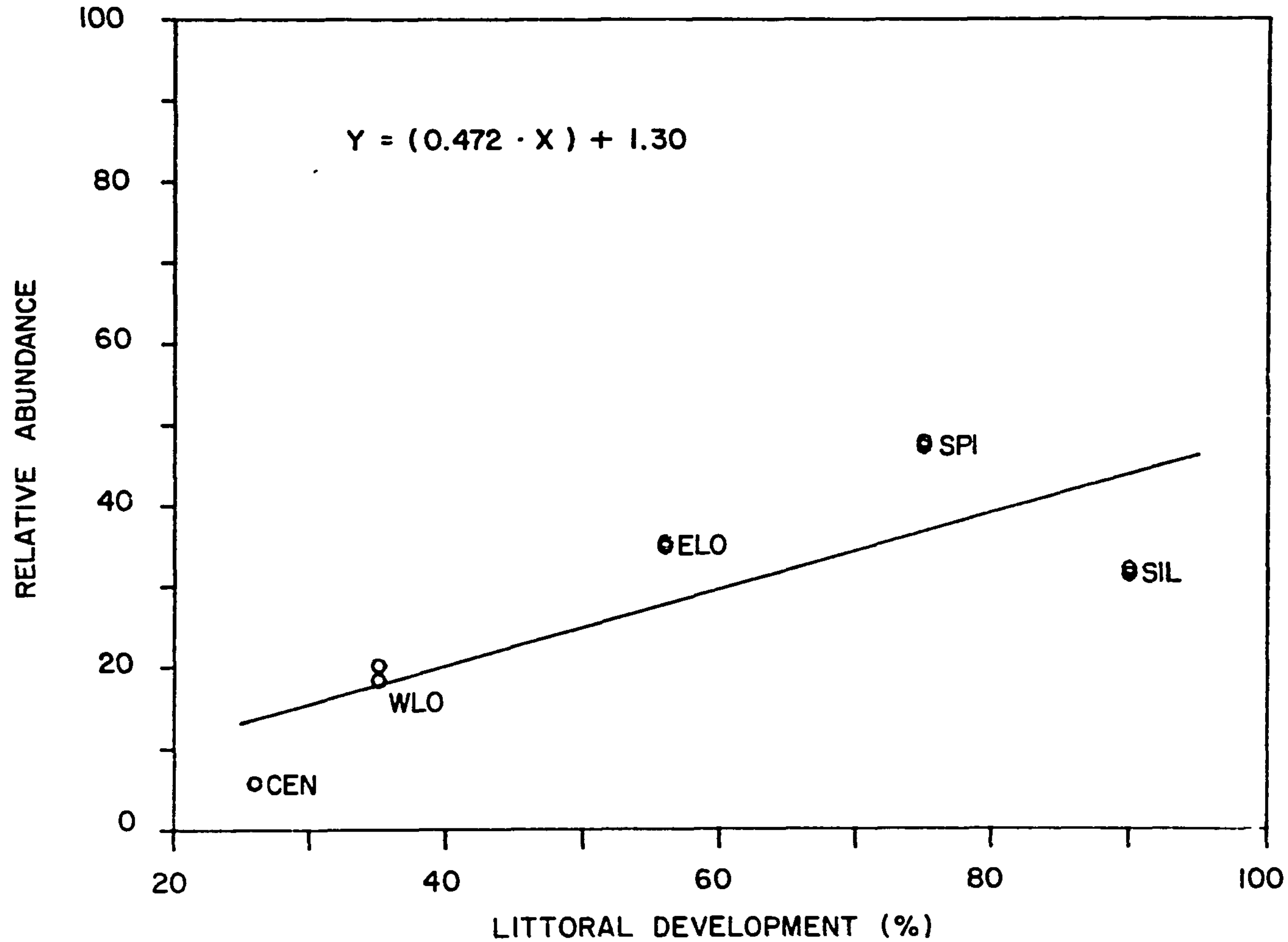

Figure 118. Relation between the relative abundance of littoral/benthic diatoms and percent littoral development in each lake. Center Lake, CEN; Lake West Okoboji, LWO; Lake East Okoboji, LEO; Spirit Lake, SPI; Silver Lake, SIL

been well documented (Bachmann and Jones, 1974; Bachmann et al., 1980). What then, do the present plankton diatom assemblages indicate regarding this question of trophic direction? Are there indicator species signalling the direction of future trends?

Water quality indicators

My investigation of indicator species in the Lake District draws heavily upon observations of trophic status equated to diatom taxa by other researchers. In particular, the studies of Lake Michigan plankton diatom communities, by Stoermer and Yang (1969, 1970), Holland (1969), and Holland and Beeton (1972), and of Minnesota fossil diatoms by Bradbury (1975) and Brugman (1983) were of special interest because the reported diatom assemblages were similar to those of the Okoboji Region lakes.

Selected diatoms from the Lake District, their apparent trophic preferences (based upon the scientific literature) and relative abundances in the lakes sampled are listed in Table 255. Three categories of diatoms were recognized: (1) species characteristic of oligotrophic-mesotrophic habitats (*Cyclotella compta* through *Fragilaria pinnata*); (2) mesotrophic-eutrophic taxa (*Cyclotella meneghiniana* through *Fragilaria capucina* v. mesolepta); and (3) eutrophic diatoms (*Stephanodiscus tenuis* and *Nitzschia dissipata*). The number of species, relative abundance, and distribution of

Table 255. Apparent trophic preferences and abundances for selected diatom species. Oligotrophic, O; mesotrophic, M; eutrophic, E. Data on trophic preferences from Stoermer and Yang, 1970; Holland, 1969; Holland and Beeton, 1972. Silver Lake, SIL; Lake West Okoboji, LWO; Lake East Okoboji, LEO; Center Lake, CEN; Spirit Lake, SPI

Selected Taxon	Trophic Preference	Abundance Lake District				
		SIL	LWO	CEN	SPI	LEO
Cyclotella compta	O,M	r		r		r
Cyclotella stelligera	O,M	r			r	
Melosira italica	O,M		r		c	r
Melosira islandica	O,M					r
Fragilaria pinnata	O,M	r	r	r	r	r
Cyclotella meneghiniana	M,E	r	r	r	r	r
Asterionella formosa	M,E	r	c	c	o	o
Fragilaria crotonensis	M,E	c	c	c	o	r
Stephanodiscus minutus	M,E	r	r		r	
Stephanodiscus niagarae	M,E	o	r	c	r	r
Stephanodiscus hantzschii	M,E	c	c	r	r	c
Melosira ambigua	M,E	r	r	o		r
Melosira granulata	M,E	r	c	c	o	r
Melosira granulata v. *angustissima*	M,E		c	c	o	r
Fragilaria capucina	M,E	c			r	
Fragilaria capucina v. *mesolepta*	M,E	a	c	o	c	c
Stephanodiscus tenuis	E	r	r	r	r	r
Nitzschia dissipata	E	r	r	r	r	o

oligotrophic indicators were markedly reduced when compared to those species considered indicative of mesotrophic to eutrophic conditions. In addition, many of the taxa that I collected from the Region are reported as pollution-tolerant entities. Palmer (1969) compiled a list of algal genera and species tollerant to organic pollution. Of the 80 most pollution-tolerant species of algae that he listed, 21 species were diatoms. Twenty of these entities have been recorded from the Lake Region (Table 256).

What changes do we see in the plankton diatom floras of the lakes, and what do these changes indicate with regard to water quality? Unfortunately, Volker's (1963) study of Lake East Okoboji is the only historical summary that is comparable to the present investigation. Direct comparisons with the studies of Lake West Okoboji (Stoermer, 1963a) and Spirit Lake (Krohn et al., 1974) are difficult, due to the general lack of quantification of the data. Regardless, several trends in selected plankton diatom taxa were apparent, and are our best indicators of water quality changes.

Stephanodiscus hantzschii Grun. This entity was reported only from Spirit Lake (Krohn et al., 1974) and Lake West Okoboji (Stoermer, 1963a), and appeared to be uncommon in plankton collections. I observed it to be a perennial species in all of the lakes, common, and most abundant during the late winter and spring (Table 232; Figure 74). The spatial and

Table 256. List of the most pollution-tolerant diatoms recorded by Palmer (1969) and present in plankton collections from the Lake Region

Nitzschia palea	Diatoma vulgare
Synedra ulna	Navicula viridula
Melosira varians	Synedra acus
Cyclotella meneghiana	Cocconeis placentula
Nitzschia acicularis	Nitzschia sigmoidea
Navicula cryptocephala	Achnanthes minutissima
Gomphonema parvulum	Cymatopleura solea
Stephanodiscus hantzschii	Fragilaria crotonensis
Surirella ovata	Melosira granulata
Navicula cuspidata	Fragilaria capucina

temporal distributions of this species have increased. This taxon is reported to be favored by nutrient enrichment, flourishing in mesotrophic waters (Stoermer and Yang, 1970), and characteristic of shallow, alkaline eutrophic lakes (Holland, 1969; and Brugman, 1983). Stephanodiscus hantzschii was revealed as the major indicator of human disturbance in Minnesota lakes (Bradbury, 1975).

Stephanodiscus niagarae Ehr. Historically, uncommon in Lake West Okoboji (Stoermer, 1963a); present in Spirit Lake (Krohn et al., 1974); and absent from Lake East Okoboji (Volker, 1963). During this investigation, this species remained uncommon in lakes East and West Okoboji, but was abundant in Center Lake and Silver Lake (Table 234; Figure 76). This entity has also been recorded from shallow, eutrophic lakes (Brugman, 1983), and is indicative of eutrophic conditions (Holland, 1969; Stoermer and Yang, 1970; Burgman, 1983).

Stephanodiscus tenuis Hust. A new taxon recorded for the Lake District, which has become common in the plankton of all the lakes. Stoermer and Yang (1969, 1970) reported that this entity was a recently introduced eutrophic species in Lake Michigan. This would appear to be the trend for the Okoboji Region. During this investigation, it was a perennial species, best developed during late winter, spring, and summer; most abundant in the plankton of lakes East and West Okoboji and Spirit Lake (Table 236; Figure 78).

Fragilaria capucina v. *mesolepta* Rabh. This taxon was abundant, often dominant, in the winter plankton of lakes East and West Okoboji (Volker, 1963; Stoermer, 1963a), and was recorded in Spirit Lake (Krohn et al., 1974). Recent collections imply that its distribution and abundance have probably increased throughout the Lake District (Table 81; Figure 36). It has become a common entity in all of the lakes, and was observed in collections made during all seasons, with blooms occurring during both the winter/spring and summer periods. *Fragilaria capucina* Desmazieres has been reported from nutrient enriched environments (Holland and Beeton, 1972). Stoermer and Yang (1969, 1970) reported that *Fragilaria capucina* v. *mesolepta* had the same distribution and frequency of occurrence as the nominate variety. this implies that this entity is also indicative of eutrophic environments.

It is apparent that the plankton diatom flora of the Lake District contained many species characteristic of advanced stages of eutrophication. All the plankton diatom assemblages identified from the lakes of the Region contained species recorded as indicators of nutrient enrichment by other investigators (Hutchinson, 1967; Wetzel, 1975; and Brugman, 1983). Though it is impossible to define how the plankton diatom flora has changed historically in each of the lakes, and what these changes may suggest with regard to trophic conditions, certain generalities appear to hold for the Lake

District as a whole.

1. Taxa known to be associated with moderate to high levels of pollution (see above) have increased their abundance and distribution, or are new forms occurring in the plankton, not reported by earlier investigators (e.g., Stephanodiscus tenuis), and are now major components of the phytoplankton communities throughout the Region.

2. These trends in diatom species occurrence suggest, that water quality conditions within the Region are not improving, despite pollution abatement procedures. High background nutrient concentrations; wind mixing of nutrient laden sediments; and the slow rate of turnover for many of the lakes may thwart our efforts to "right the wrongs of ages past."

SUMMARY

1. Two hundred and forty-eight diatoms taxa encompassing 33 genera, 11 families, and 7 orders were identified from the plankton communities of the study lakes.

2. Spirit Lake had the largest number of taxa recorded and Center Lake had the fewest.

3. The plankton diatom flora of the Region was characterized by an abundance of pennate taxa. Species of the Araphidineae generally dominated the plankton. The centric diatoms were the second most abundant group.

4. The majority of the taxa recorded for the Region were meroplanktonic and pseudoplanktonic (littoral/benthic) forms. Only *Asterionella formosa* could be considered a truly euplanktonic species.

5. The pseudoplankton had the greatest diversity, while the meroplankton had the greatest relative abundance.

6. The abundance of pseudoplanktonic forms in the plankton was a function of the percent littoral development for each lake. Lake morphometry, fetch, and transparency were important to this relationship.

7. While the dominant species varied spatially and temporally within each lake, the overall species composition of the floras was remarkably similar, as indicated by cluster analysis of the lakes across taxa.

8. The taxa reported in this investigation have the following autecological classifications: alkalibiontic, eutrophic, oligohalobous, saproxenous, limnobiontic, lake, and meroplanktonic (tychoplanktonic) or pseudoplanktonic (littoral/benthic).

9. It is apparent that the plankton diatom flora of the Region contains entities characteristic of nutrient enrichment (eutrophication). Pollution tolerant diatoms have increased their importance in the plankton communities.

10. Indicator species within the plankton diatom communities of the major lakes suggest that water quality is not improving within the Region.

LITERATURE CITED

Bachmann, R. W. 1965. Some chemical characteristics of Iowa lakes and reservoirs. Proc. Iowa Acad. Sci. 72:238-243.

Bachmann, R. W. and J. R. Jones. 1974. Water quality in the Iowa Great Lakes. A report to the Iowa Great Lakes Water Quality control Plan. Project No. 1779. Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa.

Bachmann, R. W., M. R. Johnson, M. V. Moore and T. A. Noonan. 1980. Clean lakes classification study of Iowa's lakes for restoration. Final report to the Iowa Conservation Commission. Des Moines, Iowa.

Beckert, C. A. 1977. An investigation of the Skunk River algal flora under low flow conditions. M.S. Thesis. Iowa State University Library, Ames, Iowa. 128 pp.

Begres, F. M. 1971. The diatoms of Clear Lake and Ventura Marsh, Iowa. Ph.D. Thesis. Iowa State University Library, Ames, Iowa. 199 pp.

Birge, E. A. and C. Juday. 1920. A limnological reconnaissance of West Okoboji. Univ. Iowa Studies Nat. Hist. 9:1-56.

Bloom, S. A., J. L. Simon and V. D. Hunter. 1977. A package of computer programs for benthic community analysis. Bull. Mar. Sci. 27:577-580.

Blum, J. L. 1957. An ecological study of the algae of the Saline River, Michigan. Hydrobiologia 9:361-405.

Bock, W. 1952. Floristisch-okologische untersuchung der Algenvegetation periodischer Gewasser im sudlichen Teil des Maindreieckes. Arch. f. Hydrobiol. 47 (1):9-74.

Bovbjerg, R. V. and M. J. Ulmer. 1960. An ecological catalog of the Lake Okoboji gastropods. Proc. Iowa Acad. Sci. 67:569-577.

Boyer, C. S. 1916. The Diatomaceae of Philadelphia and vicinity. J. B. Lippincott, Philadelphia. 143 pp.

Bradbury, J. P. 1975. Diatom stratigraphy and human settlement in Minnesota. Geol. Soc. Am. Special Paper 171. 74 pp.

Brugman, R. B. 1983. The relationship between fossil diatom assemblages and limnological conditions. Hydrobiologia 98:223-235.

Buchanan, R. E. 1907. Notes on the algae of Iowa. Proc. Iowa Acad. Sci. 14:47-84.

Budde, H. 1931. Die Algenflora westfalischer Salinen und Salzgewasser. Arch. f. Hydrobiol. 23(3);462-490.

Carman, J. E. 1917. The Pleistocene geology of Northwestern Iowa. Iowa Geol. Surv. Ann. Rept. 26:233-445.

Cholnoky, B. J. 1968. Die Okologie der Diatomeen in Binnengewasser. J. Cramer, Lehre. 699 pp.

Christensen, C. L. 1976. Notes on Iowa diatoms XI: A study of the genus Pinnularia from Dead Man's Lake. Proc. Iowa Acad. Sci. 83:81-87.

Cleve-Euler, A. 1952. Die Diatomeen von Schweden und Finnland. Teil V. Schluss. Kongliga Svenska Vetenskaps-Akademiens Handlingar, Fjarde Serien 3(3):1-153.

Cleve-Euler, A. 1953. Die Diatomeen von Schweden und Finnland. Teil III. Mononaphidineae, Biraphideae 1. Kongliga Svenska Vetenskaps-Akademiens Handlingar, Fjarde Serien 4(5):1-255.

Collins, G. B. 1968. Implications of diatom succession in postglacial sediments from two sites in northern Iowa. Ph.D. Thesis. Iowa State University Library, Ames, Iowa. 195 pp.

Collins, G. B. and R. G. Kalinsky. 1977. Studies on Ohio diatoms: I. Diatoms of the Scioto River Basin. II. Referenced checklist of diatoms from Ohio exclusive of Lake Erie and the Ohio River. Bull. Ohio Biological Survey. 5(3):1-76.

Cormack, R. H. 1971. A review of classification. J. R. Statist. Soc. 134:321-367.

Crum, G. H. and R. W. Bachmann. 1973. Submersed aquatic macrophytes of the Iowa Great Lakes Region. Iowa State J. Res. 48:147-173.

Cupp, E. E. 1943. Marine plankton diatoms of the west coast of North America. Univ. of Calif. Press, Berkeley and Los Angeles. 233 pp.

Dodd, J. D. 1971. The ecology of diatoms in hardwater habitats. U.S. Environ. Protect. Agency. Water Poll. Cont. Series No. 18050DIE. 63 pp.

Dodd, J. D. and E. F. Stoermer. 1962. Notes on Iowa diatoms I. An interesting collection from a moss lichen habitat. Proc. Iowa Acad. Sci. 69:83-87.

Dodd, J. D., R. M. Webster, G. Collins, and L. Wehr. 1968. A consideration of pollen, diatoms, and other remains in postglacial sediments. Proc. Iowa Acad. Sci. 75:197-209.

Drum, R. W. 1962. Notes on Iowa diatoms III. Occurrence of the genus *Pleurosigma* in the Des Moines River. Proc. Iowa Acad. Sci. 69:96-98.

Drum, R. W. 1963. Notes on Iowa diatoms. VI. Frustular observations in *Surirella ovalis*. Proc. Iowa. Acad. Sci. 71:51-55.

Drum, R. W. 1964. Ecology of diatoms in the Des Moines River. Ph.D. Thesis. Iowa State University Library, Ames, Iowa. 113 pp.

Edwards, M. L. 1974. Notes on diatoms from waters of two drainage tiles in northwest Iowa. Proc. Iowa Acad. Sci. 81:61-67.

Edwards, M. L. and C. L. Christensen. 1973. Notes on autumn collections of diatoms from Brewer's Creek, Hamilton Co., Iowa. Proc. Iowa Acad. Sci. 79:25-30.

Fee, E. F. 1967. The diatoms in a small Iowa creek. Iowa State J. Sci. 41:393-411.

Fee, E. J. and R. W. Drum. 1965. Diatoms epizoic on copepods parasitizing fishes in the Des Moines River, Iowa. Am. Midland Nat. 74:318-324.

Fjerdingstadt, E. 1950. The microflora of the River Molleaa. Folia Limnol. Scand. 5:1-123.

Flint, R. F. 1957. Glacial and Pleistocene Geology. John Wiley and Sons, New York. 553 pp.

Foged, N. 1948. Diatoms in water-courses in Funen. Dansk Bot. Ark. 12:1-112.

Foged, N. 1949. Diatoms in the Salt Bog of Langemose in East Funen. Dansk Bot. Ark. 13:1-33.

Foged, N. 1953. Diatoms from West Greenland. Medd. Om Gronl. 147:1-86.

Foged, N. 1954. On the diatom flora of some Funen lakes. Folia Limnol. Scand. 6:1-75.

Foged, N. 1958. The diatoms in the basalt area and adjoining areas of archean rock in West Greenland. Medd. Om Gronl. 156:1-146.

Foged, N. 1964. Freshwater diatoms from Spitsbergen. Tromso Mus. Skr. 11:1-159.

Foged, N. 1968a. Diatomeerni i en postglacial boreprove fra bunden af Esrom So Danmark. Meddr. Da Geol. Foren. 18:161-180.

Foged, N. 1968b. The freshwater diatom flora of the Varanger Peninsula, North Norway. Acta Borealia A. Scientia 25:1-64.

Frenguelli, J. 1933. Diatoms de Montevideo. Ostenia Coleccion de Trabajos Botanicos, Montevideo 1933: 122-130.

Gandhi, H. P. 1970. A further contribution to the Jog-Falls, Mysore State, India. Nova Hedwigia, Beihefte 31:757-813.

Gemeinhardt, K. 1926. Die Gattung Synedra in systematischer, zytologischer und okologischer Bezienhung. Pflanzenforschung 6:1-88.

Granetti, B. 1968. Revisione critica di Navicula nigrii, Navicula casertana, Pinnularia passerinii, Stauroneis vergania and Synedra juliana De Notaria. Giornale Botanico Italiano 102:427-437.

Gudmundson, B. 1969. Phytoplankton fluctuations in the Des Moines River, Iowa. Ph.D. Thesis. Iowa State University Library, Ames, Iowa. 111 pp.

Hasle, G. R. and B. R. Heimdal. 1970. Some species of the species of the centric diatom genus Thalassiosira studied in the light and electron microscopes. Nova Hedw. Beinhefte 31:543-581.

Hayek, J. M. W. and R. L. Hulbary. 1956. A survey of soil diatoms. Proc. Iowa Acad. Sci. 63:327-338.

Heiden, H. and A. W. Kolbe. 1928. Die Marinen Diatomeen der Deutschen Sudpolar-Expedition, 1901-1903. Deutsche Sudpolar Expedition, 8, No. 5:450-714.

Hendey, N. I. 1937. The plankton diatoms of the Southern seas. Discovery Reports 16:151-364.

Hohn, M. H. and J. Hellerman. 1963. The taxonomy and structure of diatom populations from three eastern North American rivers using three sampling methods. Trans. Am. Micros. Soc. 82(3):250 - 329.

Holland, R. E. 1969. Seasonal fluctuations of Lake Michigan diatoms. Limnol. Oceanogr. 14:423-436.

Holland, R. E. and A. M. Beeton. 1972. Significance to eutrophication of spatial differences in nutrients and diatoms in Lake Michigan. Limnol. Oceanogr. 17: 88-96.

Hornung, H. 1959. Floristisch-okologische untersuchungen an der Echaz unter besonderer Berucksichtigung der Verunreinigung durch Abwasser. Arch. f. Hydrobiol. 55:52-126.

Hosseini, S. M. 1979. Seasonal changes of diatom communities on artificial substrates in Lake West Okoboji, Iowa. M.S. Thesis. Iowa State University Library, Ames, Iowa. 181 pp.

Hostetter, H. P. and E. F. Stoermer. 1968. A study of the vertical distribution of periphyton diatoms in Lake West Okoboji, Iowa. Proc. Iowa Acad. Sci. 75:42-47.

Hungerford, J. J. 1972. Diatoms from seven Iowa rivers. Iowa State Coll. J. Sci. 46:375-379.

Huntsman, S. D. 1966. The stalk polysaccharide of the diatom, Gomphonema olivaceum. Ph.D. Thesis. Iowa State University Library, Ames, Iowa.

Hustedt, F. 1930a. Bacillariophyta (Diatomeae). In A. Pascher, ed. Die Susswasser-Flora Mitteleuropas, Vol. 10. Gustav Fischer, Jena. 466 pp.

Hustedt, F. 1930b. Die Kieselalgen Deutschlands, Osterreichs und der Schweiz unter Bercksichtigung der ubrigen Lander Europas sowie der angrenzenden Meersgebiete. In L. Rabenhorst, ed. Kryptogamen-flora von Deutschland, Osterreich und der Schweiz. Band 7, Teil 1. Akademische Verlagsgesellschaft Geest und Portig K.-G., Leipzig. Johnson Reprint Corporation, New York. 920 pp.

Hustedt, F. 1937 - 1938. Systematische and Okologische Untersuchungen uber die Diatomeenflora von Java, Bali and Samatra. Arch. f. Hydrobiol., Supplement-Band 15:131-177; 15;187-295; and 15:393-506.

Hustedt, F. 1939. Die diatomeenflora des kustengebietes der Nordsee von Dollart bis zur Elbemundung I. Abh. Nat. ver. Bremen. 31:571-677.

Hustedt, F. 1942. Suswasser-Diatomeen des indomalayischen Archipels und der Hawaii-Inseln. Int. Rev. Ges. Hydrobiol. 42:1:252.

Hustedt, F. 1949. Susswasser-Diatomeen aus dem Albert-National Park in Belgisch-Kongo. In Institute des Pares Nationaux due Congo Belege. Exploration du Parc Albert 8:1-199.

Hustedt, F. 1954. Die Diatomeenflora des interglazials von Oberohe in der Luneburer Neide. Abhandlungen herausgegeben vom Naturwissenschaftlichen Verein zu Bremen 33:431-456.

Hustedt, F. 1955. Marine littoral diatoms of Beaufort, North Carolina. Duke Univ. Marine St. Bull. #6. Duke Univ. Press, Durham, N.C. 67 pp.

Hustedt, F. 1957. Die Diatomeenflora des Flusssystems der Weser im Gebiet der Hamsestadt Bremen. Abhandl. Naturwiss. Ver. Bremen. 34:181-440.

Hustedt, F. 1959a. Die Diatomeenflora des Salzlacken-gebietes im osterreichischen Burgenland. Osterreichische Akademie der Wissenschaften, mathematisch-naturwissen-schaftliche Klasse, Abteilung 1, Sitzungsberichte 168:387-452.

Hustedt, F. 1959b. Die Kiesellalgen Deutschlands, Osterreichs und der Schweiz unter Berucksichtigung der ubrigen Lander Europas sowie der angrenzenden Meersgebiete. In L. Rabenhorst, ed. Kryptogamenflora von Deutschland, Osterreich und der Schweiz. Band 7, Teil 2, Lieferung 1-6. Akademische Verlagsgesellschaft Geest und Portig K.-G., Leipzig. Johnson Reprint Corporation, New York. 845 pp.

Hustedt, F. 1961-1962. Die Kieselalgen Deutschlands. Osterreichs und der Schweiz unter Berucksichtigung der ubrigen Lander Europas sowie der angrenzenden Meersgebiete. In L. Rabenhorst, ed. Kryptogamenflora von Deutschland, Osterreich und der Schweiz. Band 7, Teil 3, Lieferung 1-4. Akademische Verlagsgesellschaft Geest und Portig K.-G., Leipzig. Johnson Reprint Corporation, New York. 816 pp.

Hutchinson, G. E. 1967. A treatise on Limnology. II. Introduction to Lake Biology and the Limnoplankton. New York, John Wiley and Sons, Inc. 1115 pp.

Jackson, D. C. 1980. A study of the diatom genus Pinnularia in Iowa. Ph.D. Thesis. Iowa State University Ames, Iowa. 251 pp.

Jones, J. R. and R. W. Bachmann. 1975. Algal response to nutrient inputs in some Iowa lakes. Verh. Int. Verein. Limnol. 19:904-910.

Jones, J. R. and R. W. Bachmann. 1976. Prediction of phosphorus and chlorophyll levels in lakes. J. Water Pollut. Control Fed. 48:2176-2182.

Jones, J. R. and R. W. Bachmann. 1978. Trophic status of Iowa lakes in relation to origin and glacial geology. Hydrobiologia 57(3):267-273.

Jorgensen, E. G. 1948. Diatom communities in some Danish lakes and ponds. D. Kgl. Danske Vidensk. Selskab, Biol. Skrifter 5:1-140.

Kay, D. H. 1965. Techniques for electron microscopy. 2nd edition. F. A. Davis, Philadelphia. 560 pp.

Kolbe, R. W. 1927. Zur Okologie, Morphologie, und Systematik der Brackwasser-Diatomeen. Pflanzenforschung. 7:1-146.

Kolkwitz, R. 1914. Pflanzenphysiologie. Plant physiology. Gustav Fischer, Jena.

Kolkwitz, R. and M. Marsson. 1908. Okologie der pflanzlichen Saprobien. Ber. Deut. Bot. Ges. 26: 505-519.

Krohn, M., M. Edwards and J. D. Dodd. 1974. Notes on Iowa diatoms XII. Common diatoms and Big Spirit Lake. Proc. Iowa Acad. Sci. 81(3):108-110.

Kutkukn, J. H. 1958. The plankton of North Twin Lake, with particular reference to the summer of 1955. Iowa State College J. Sci. 32:419-450.

Loescher, J. H. 1971. Soil diatoms from a native Iowa prairie. Ph.D. Thesis. Iowa State Univ. Library, Ames, Iowa.

Lowe, R. L. 1970. Taxonomic and ecological analyses of diatom communities in drainage ditches. Ph.D. Thesis. Iowa State Univ. Library, Ames, Iowa. 302 pp.

Lowe, R. L. 1972. Notes on Iowa diatoms X. New and rare diatoms from Iowa. Proc. Iowa Acad. Sci. 79:66-69.

Lowe, R. L. 1974. Environmental requirements and pollution tolerance of freshwater diatoms. National Environmental Research Center, U.S. Environmental Protection Agency, Cincinnati, Ohio. 334 pp.

Lowe, R. L. and R. E. Crang. 1972. The ultrastructure and morphological variability of the frustule of Stephanodiscus invisitatus Hohn and Hellerman. J. Phycol. 8:256-259.

Mayer, A. 1918. Bacillariales der Umgegend von Ortenburg (Niederbayern). Kryptogamische Forschugen 1:122-129.

Mayer, A. 1928. Die bayerischen Gomphonemen. Bayerische Botanische Gesellschaft in Regensburg, Denkschniften 13, Neue Folge 11:83-128.

McIntire, C. D. 1966. Some effects of current velocity on periphyton communities in laboratory streams. Hydrobiologia 27:559-570.

Manguin, C. D. 1952. Les diatomees fossiles du bassin thermo-mineral D'Antsirabe. Mem. Inst. Sci. Madagascar 4:1-57.

Merilainen, J. 1967. The diatom flora and the hydrogen-ion concentration of the water. Ann. Bot. Fenn. 4:51-58.

Muller, O. 1911. Beitrage zur Flora von Afrika. xxxvii. Berichte uber die botanischen Ergebnisse der Nyassa-See-und Kinga-Gebirgs-Expedition der Hermann-und Elise-geb. Heckman-Wentzelstiftung. viii. Bacillariaceen aus dem Nyassalande und einigen benachbarten Gebieten. Botanische Jahrbucher 45:69-122.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. New York, John Wiley and Sons. 547 pp.

Myers, P. C. 1899. Report on the diatoms of Iowa. Proc. Iowa Acad. Sci. 6:47-52.

Niessen, H. 1956. Okologische Untersuchungen uber die Diatomeen Und Desmidiaceen des Murnauer Moores. Arch. f. Hydrobiol. 51:281-375.

Ohl, L. 1964. Notes on Iowa diatoms VIII. A winter bloom of Synedra acus in a farm pond. Proc. Iowa Acad. Sci. 71:67-71.

Ohl, L. 1965. Diatoms of Iowa farm ponds. Ph.D. Thesis. Iowa State Univ. Library, Ames, Iowa. 199 pp.

Orloci, L. 1978. Multivariate Analysis in Vegetation Research. Dr. W. Funk, Publishers, Boston. 451 pp.

Palmer, C. M. 1969. A composite rating of algae tolerating organic pollution. J. Phycol. 5:78-82.

Patrick, R. and L. R. Freese. 1961. Diatoms (Bacillariophyceae) from northern Alaska. Proc. Acad. Nat. Sci. Phil. 112:129-293.

Patrick, R. and C. W. Reimer. 1966. The diatoms of the United States, exclusive of Alaska and Hawaii. Vol. 1. Acad. Nat. Sci. Phil. Monograph No. 13. 688 pp.

Patrick, R. and C. W. Reimer. 1975. The diatoms of the United States, exclusive of Alaska and Hawaii. Vol. 2, Part 1. Acad. Nat. Sci. Phil. Monograph No. 13. 213 pp.

Petersen, J. B. 1943. Some halobion spectra (diatoms). D. Kgl. Dansk Vidensk. Selsk., Biol. Medd. 17:1-95.

Poole, R. W. 1974. An introduction to quantitative ecology. New York, McGraw-Hill Book Co. 532 pp.

Proschkina-Lavrenko, A. I. 1959. De Cyclotella caspia Grun. Moskva. Bot. Mater. (Moscow) 12:69-75.

Raabe, H. 1951. Die Diatomeenflora der ostholsteinischen Fliessgewasser. Arch. f. Hydrobiol. 44:521-688.

Raschke, R. 1968. Algal periodicity, primary productivity, and waste reclamation in a tertiary sewage stabilization pond ecosystem. Ph.D. Thesis. Iowa State Univ. Library, Ames, Iowa. 111 pp.

Reimann, B. E. F., J. M. C. Lewin and R. L. L. Guillard. 1963. Cyclotella crypta, a new brackish-water diatom species. Phycologia 3:75-84.

Reimer, C. W. 1970. Some diatoms (Bacillariophyceae) from Cayler Prairie. In Diatomaceae II. Nova Hedwigia 31:235-249.

Roeder, D. R. 1976. Algal communities of the Skunk River, Iowa, with special reference to the epipelon. Ph.D. Thesis. Iowa State University Library, Ames, Iowa. 212 pp.

Ruhe, R. V. 1952. Topographic discontinuities of the Des Moines Lobe. Am. J. Sci. 250:46-56.

Scheele, M. 1952. Systemische-okologische untersuchungen uber die Diatommenflora der Fulda. Arch. f. Hydrobiol. 46:305-423.

Schmidt, A. 1874 - 1959. Atlas der Diatomaceen-Kunde. R. Reisland, Leipzig. Heft 1-120, Tafeln 1-480. (Tafeln 1-212, A. Schmidt, 1874-1897; tafeln 213-216, M. Schmidt, 1899; Tafeln 217-232, Fr. Fricke, 1899-1902; Tafeln 241-244, H. Heiden, 1903; Tafeln 245-246, O. Muller, 1904; Tafeln 247-248, M. Schmidt and Fr. Fricke, 1904; Tafeln 249-256, Fr. Fricke, 1904-1905; Tafeln 257-264, H. Heiden, 1905-1906; Tafel 265, Fr. Fricke, 1906; Tafel 266, M. Schmidt and Fr. Fricke, 1906; Tafeln 267-268, Fr. Fricke, 1906; Tafeln 269-274, Fr. Hustedt, 1911; Tafeln 275-277, Fr.

Fricke and Fr. Hustedt, 1911-1912; Tafeln 278-283, Fr. Hustedt, 1912; Tafeln 285-290, Fr. Hustedt, 1913; Tafel 291, Fr. Fricke and Fr. Hustedt, 1913; Tafeln 292-420, Fr. Hustedt, 1913-1958; Tafeln 421-432 not issued; Tafeln 433-480, Fr. Hustedt, 1940-1959).

Schmidt, D. J. and E. J. Fee. 1967. Planktonic diatoms from the Coralville Reservoir. Proc. Iowa Acad. Sci. 74:17-19.

Schroeder, J. 1939. Die Algenflora der Mulde. Pflanzenforschung 21:1-88.

Shapiro, J., J. B. Lundquist and R.E. Carlson. 1975. Involving the public in limnology - an approach to communication. Verh. Int. Verein. Limnol. 19:866-874.

Shobe, W. R. 1967. A study of diatom communities in a hard-water stream. Ph.D. Thesis. Iowa State Univ. Library, Ames, Iowa. 109 pp.

Shobe, W. R., E. F. Stoermer, and J. D. Dodd. 1963. Notes on Iowa diatoms IV. The diatoms in a northwest Iowa fen. Proc. Iowa Acad. Sci. 70:71-74.

Silva, P. C. 1962. Classification of algae. Appendix A in Physiology and Biochemistry of algae. R. A. Lewin, ed. Academic Press, New York.

Simonsen, R. 1962. Untersuchungen zur Systematik und Okologie der Boden Diatomeen der Westlichen Ostsee. Int. Rev. Ges. Hydrobiol. Beihefte 35:267-285.

Skvortzow, B. J. 1938. Diatoms from Kenon Lake, Transbaikalia, Siberia. Philippine J. Sci. 65:399-424.

Smith, R. L. 1966. Ecology and field biology. Harper and Row, New York, New York. 686 pp.

Starrett, W. C. and P. Patrick. 1952. Net plankton and bottom microflora of the Des Moines River. Proc. Acad. Nat. Sci. Phila. 104:219-243.

Stoermer, E. F. 1962. Notes on Iowa diatoms II. Species distribution in a subaerial habitat. Proc. Iowa Acad. Sci. 69:87-95.

Stoermer, E. F. 1963a. Post-pleistocene diatoms from Lake West Okoboji, Iowa. Ph.D. Thesis. Iowa State Univ. Library, Ames, Iowa. 214 pp.

Stoermer, E. F. 1963b. New taxa and new United States records of the diatom genus, Neidium, from Lake West Okoboji, Iowa. Notula Naturae Acad. Nat. Sci. Phila. 358:1-9.

Stoermer, E. F. 1964. Notes on Iowa diatoms VII. Rare and little known diatoms from Iowa. Proc. Iowa Acad. Sci. 71:55-66.

Stoermer, E. F. and J. J. Yang. 1969. Plankton diatom assemblages in Lake Michigan. Univ. Michigan, Great Lakes Research Div. spec. Rep. No. 47. 268 pp.

Stoermer, E. F. and J. J. Yang. 1970. Distribution and relative abundance of plankton diatoms in Lake Michigan. Great Lakes Research Division, Pub. No. 16. Univ. Mich., Ann Arbor, Mich. 64 pp.

Thomas, A. O. 1913. The glacial story of the Lake Okoboji region. Okoboji Protective Assoc. Bull. 9:17-21.

Tilton, J. L. 1916a. Records of oscillations in lake level and records of lake temperature, and of meterology, secured at the MacBride Lakeside Laboratory, Lake Okoboji, Iowa. July, 1916. Proc. Iowa Acad. Sci. 23:91-102.

Tilton, J. L. 1916b. The origin of Lake Okoboji. Okoboji Protective Assoc. Bull. 12:8-11.

U.S. Environmental Protection Agency. 1975. A compendium of lake and reservoir data collected by the National Eutrophication Survey in the northeast and north central United States. Working Paper No. 474. Corvallis and Las Vegas. 210 pp.

van der Werff, A. 1955. A new method of concentrating and cleaning diatoms and other organisms. Verh. Int. Verein. Limnol. 12:276-277.

Volker, R. 1962. Preliminary aspects of an ecological investigation of Lake East Okoboji, Iowa. Proc. Iowa Acad. Sci. 69:99-107.

Volker, R. 1963. Diatoms from the plankton of Lake East Okoboji, Iowa. M.S. Thesis. Iowa State Univ. Library, Ames, Iowa. 152 pp.

Volker, R. and S. G. Smith. 1965. Changes in the aquatic vascular flora of Lake East Okoboji in historic times. Proc. Iowa Acad. Sci. 72:65-72.

Vollenweider, R. A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to phosphorus and nitrogen as factors in eutrophication. Tech. Rept. to O.E.C.D., Paris, DAS/CSI68. 27:1-182.

Wetzel, R. G. 1975. Limnology. W. G. Saunders Co., Philadelphia, Penn. 743 pp.

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